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Science and Technology

(From the Month's News Releases)

Circuit-Breaker

An inexpensive vacuum switch that shuts off the power source when the liquid supply runs dry can be used with electric motors and gasoline engines where the safety of equipment depends on a suction-delivered lubricant, fuel, water, or similar liquid. It may also be used as a warning control where operating conditions depend on a vacuum, such as vacuum firing in ceramics manufacture.

Clad Metal

A small automatic machine that will produce a perfect chemical bond between strips of lead and steel up to $\frac{1}{4}'' \times 12''$ is designed to carry its own lead supply or not, as circumstances dictate. The machine may run free or be operated on a track, and the whole carriage may be turned to clad lead on either the right or the left side. A hand-operated model has also been designed, to burn lead to lead, as in welding sheet lead and pipe.

Flavor Recovery

The aromas ordinarily lost in making fruit preserves can now be recovered and returned to the preserves or used to give a natural zest to beverages, fountain sirups, confectionary, and ice cream. The new process was developed by the U. S. Department of Agriculture in the Eastern Regional Research Laboratory.

Geography Made Easy

A 16-inch inflatable globe is made of durable plastic and, when deflated, is flexible enough to fit in a drawer or pocket. The map of the world is reproduced in five bright colors. A circular section on the front of the box in which the deflated globe is packed provides a convenient base.

Heat Panel

A thin electrical radiant-heating panel can be cemented to the ceiling like wallpaper and should prove useful when adding a new room or in supplementing existing heat. Panels are $1/16''$ thick, come in three sizes—$4' \times 6'$, $4' \times 4'$, and $3' \times 4'$—for either 115 or 230 volts. Individual room heating may be thermostatically controlled.

Bath

By means of a self-timing electromagnet that pulls a flexible, perforated plate up and down, a water bath that obviates the necessity for stirrers or circulating systems provides complete, gentle agitation in all areas of a liquid mass, irrespective of how heavily the bath is loaded. A dual control selects and repeats the two most used temperatures, and a selector switch automatically permits proper selection of wattage.

Saw

An electric chain saw suitable for contractors, owners of orchards, farmers (including farmers' daughters), and homeowners is lighter and less bulky than a gasoline power unit. It may be used for topping, notching, and felling large trees, for limbing, flush- or under-cutting main branches, and for bucking logs and heavy lumber. One feature of the design is log-gripping teeth, which hold the saw against the work and enable the machine to spike and feed itself completely, thereby eliminating the need to jam or push the saw into the wood.

Electronic Ticket

The giant brains have now invaded the ticket-writing field to cut in half the time required to buy a ride in the wild blue yonder. Tax, fare, total cost, origin, and destination are preprinted and prepunched on the ticket, and the sales agent merely writes down the passenger's name, flight number, and date and time of departure. Ticket stubs are run through calculating machines to provide rapid revenue and accounting information.

Ink

A carbon nonclogging ink that shows good adhesion on cellulose acetate, cellulose nitrate, metacrylate, and numerous water-repellent plastic surfaces dries in two minutes and can be made water-resistant by a brief heat cure at 180°F. Although primarily designed for smooth plastics, the ink may also be used for general purpose drawing. Transparent colors, suitable for projection, are under development.

Label Holder

A transparent plastic window, $1''$ or $\frac{1}{2}''$ wide, is made in $6''$ lengths and eight colors and may be cut to any dimension needed. Backed by a strong reinforcement coated with a pressure-sensitive adhesive, the window will stick firmly to wood, leather, glass, metal, stone, paper, fiber, or plastics. It remains only to insert a typewritten or hand-lettered label. Useful for loose-leaf binders, shelves, storage-bins, or blueprint compartments.

Microwood

A thin layer of wood laminated to a paper backing makes a sheet only $.0005''$ thick that may be stamped, printed, painted, lacquered, varnished, waxed, oiled, punched, or ground and polished, either by machine or by hand. It can be affixed with ordinary adhesives to

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book covers and albums, display boards, and all types of paper and wood containers. Rolls are available in ten African and European woods, both light and dark.

For Both One- and Two-Armed Paper Hangers

An adhesive that is available in powder form and in ready-to-use mixtures may be used with either hot or cold water and does not harden immediately. This gives the amateur plenty of time to maneuver the paper around until even the most intricate patterns are correctly aligned. If stains appear on the wallpaper, they can easily be removed with a wet cloth or sponge.

Photoidentification

Industrial security officers in plants with defense contracts will be interested in a process that can be set up and operated in the personnel office by a clerk or secretary. Six minutes after the new employee is photographed, permanent identification can be in his hands, without darkroom or chemicals being required. Even plant visitors can be photoidentified while waiting at the gate.

Scrapbook Service

Clippings, photographs, diplomas, and other important personal records, up to $8'' \times 12''$ in size, are laminated between rigid plastic sheets by a mail-order service, thus preserving them practically for a lifetime.

Skin Protection

Mits of lightweight plastic will protect hands from water, dust, paint, or cleaning fluids, or they may be worn at night after applying cold cream.

Sufferers from soap-and-water or occupational dermatitis of various types may want to try a new plasticized skin cream that is not removed by normal washing. In a vanishing cream base, it is not sticky or greasy and affords prolonged protection.

A rose-scented waterless hand cleaner liquefies almost instantly and removes ink, carbon and typewriter ribbon smudge, glue, lipstick, and grease. Fortified with lanolin, it should prove especially effective for those with soap-and-water allergy, and a time-saver for the busy office worker.

Special equipment for the first commercial production of river gravel by the heavy media separation process is mounted on a separate hull lashed to the Dravo Corporation's Dredge No. 9 in the Ohio River.

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MARCH 1953

The Changing Concept in Microbiology*

SELMAN A. WAKSMAN

Dr. Waksman was born in Priluka, Russia, on July 2, 1888, but received his higher education in this country, of which he is a naturalized citizen. He has been at Rutgers University since 1918 and has been head of the Department of Microbiology since 1942. He has been the recipient of many honors: the Passano award (1947); Emil Christian Hansen award and medal of the Carlsberg Laboratorium (1947); Albert and Mary Lasker award (1948); Amory award (1948); John Scott award (1949). His distinguished career was climaxed by the award in 1952 of the Nobel prize in medicine and physiology, for his part in the discovery of streptomycin. In his honor, also, the French antibiotic manufacturers have established the Waksman Foundation, with Jacques Trefouel, director of the Institut Pasteur, as chairman. Each year the foundation sends a young French microbiologist to Rutgers for a year's training and supports a Rutgers student in France.

The Golden Age of Bacteriology

Shibasaburo Kitasato, the one hundredth anniversary of whose birth was celebrated in December, entered the field of microbiology at a critical period, at a time when the foundations were being laid for the phenomenal development of this science. Only a very few years had elapsed since Louis Pasteur, the French chemist and bacteriologist, established the importance of microbes as causative agents of fermentation and disease, thus opening wide the door for the development of microbial physiology and industrial microbiology, on the one hand, and of medical bacteriology, on the other. This was soon followed by the work of the German bacteriologist Robert Koch, who isolated and identified the causative agent of tuberculosis, which came to be known as Koch's bacillus, and who introduced new techniques for the isolation and cultivation of bacteria from natural substrates, techniques which were to revolutionize the development of bacteriology.

Kitasato, a pupil and later a colleague of Koch, added greatly to the rapidly growing knowledge of bacteria as disease-producing agents. He succeeded, in 1889,[1, 2] in cultivating the tetanus bacillus, which he found to be an obligate anaerobe. His inability to find this organism in animals that had died from tetanus suggested that the disease was a result of intoxication rather than of bacterial multiplication. This was soon followed by his studies, in collabora-

*** Based on an address delivered in Tokyo, December 20, 1952, in commemoration of the centenary of the birth of S. Kitasato.**

tion with Behring in 1890,[3] on the tetanus antitoxin. His subsequent discovery of *Clostridium* (*Bacillus*) *chauvoei*, the causative agent of blackleg in cattle, led to the enlargement of the concept of anaerobic bacteria as causative agents of disease and strengthened Pasteur's ideas of anaerobiosis as a whole. His later work on the plague bacillus[4] aided in the development of methods of combating disease-producing organisms.

Kitasato's contribution to the control of tetanus, which did much to develop the new science of immunology, may be considered as by far his most important. Immunity to infection was shown to depend on the capacity of the blood, or rather the blood serum, to render innocuous the toxin produced by the infecting organism—in this case, the tetanus bacillus (*Clostridium tetani*). The neutralizing effect of the serum was so great that it could be transferred from one animal to the bodies of other animals. This formed the basis of serum therapy and of antitoxin therapy, the last term, incidentally, being used for the first time in that classical paper of Behring and Kitasato. The word "antitoxin" thus coined took its place in the language of therapy, along with "immunotherapy" and later "chemotherapy." It was Ehrlich and Hata, the latter a pupil of Kitasato, who later discovered the first important and widely used chemotherapeutic agent, salvarsan.[5]

Baron S. Kitasato

Thus, although Pasteur may be considered as the pioneer in microbiology and Koch as the one who introduced careful techniques in the isolation and cultivation of microorganisms, Kitasato and Behring carried these ideas further into practical immunotherapy, and Ehrlich is usually considered as the father of chemotherapy. The golden age of bacteriology had now reached its midpoint.

I am not concerned here with the classical concepts of bacteriology begun by these pioneers and soon followed by numerous investigators in every civilized country in the world, with the result that many agents causing infectious diseases of man, animals, and plants were uncovered, and the principles of immunity and immunotherapy were firmly established. I should prefer to direct attention to another aspect of microbiology which has recently gained great prominence. I refer to the antagonistic relations among microbes, or the effects of one organism upon another in a mixed microbiological population, and the utilization, in the treatment of infectious diseases, of those substances, now known as antibiotics, which are responsible for the antagonistic phenomena.[6-10]

Pasteur was not particularly interested in pure cultures, which soon became recognized as the essential requirement for a proper understanding of the causation and treatment of infectious diseases. It was Robert Koch, with his theoretical "postulates," soon to be followed by Kitasato, Behring, and many others, who firmly established by new techniques the importance of pure cultures in determining the role of a particular organism in the causation of a given disease. The influence of these pioneers upon the subsequent developments in this new field of science, designated as bacteriology or microbiology, was so great that one other of Pasteur's classical observations, concerning the potential utilization of one organism for the control of a disease caused by another, remained largely unexploited for many years, either by his own students or by those of Koch and Kitasato. More than six decades were to elapse before this approach to microbiology came into its own.

According to the pure culture concept, it was necessary to isolate the causative agent of a disease in pure culture and produce the infection in experimental animals. This was followed by the recognition and, in many instances, isolation of certain toxins produced by the organism. Attempts were then made to develop specific antitoxins. This

approach led directly to developments in the new and highly important field of immunotherapy and later to an attempt at chemotherapy.

The second approach led to the recognition that in a mixed population one organism may exert a marked destructive effect upon another. This was followed by the isolation of specific chemical compounds which were produced by one organism and which had the capacity to inhibit the growth of other organisms. These compounds came to be known as antibiotics. This approach led to phenomenal developments in chemotherapy, which has often been called bacteriotherapy or antibiotic therapy.

Thus the pure culture concept in microbiology and the practical developments of disease control resulting from the work of Pasteur, Koch, and Kitasato were supplemented and even partly replaced, so far as the therapeutic aspects are concerned, by a new approach resulting from a better understanding of complex interrelationships among microorganisms. The practical utilization of these microbiological reactions has resulted in developments that have revolutionized medical practice and raised microbiology to a status never before dreamt of.

The Antibiotic Concept

The word "antibiotic," in the present accepted sense, was redefined in 1942 to embrace the products of microorganisms that have an inhibitive or destructive effect upon the growth of other microorganisms. Beginning in 1939, a number of new compounds that had antimicrobial properties were isolated in rapid succession from cultures of bacteria, fungi, and actinomycetes. The isolation of gramicidin and tyrocidine in 1939 was followed by the reisolation of penicillin in 1940–41, by the isolation of actinomycin and of streptomycin in 1940–43, and later of numerous new compounds. Before 1940, the actinomycetes were known to possess antimicrobial properties, but only two preparations, of questionable importance as antibiotics, were recognized. At present, nearly 100 compounds and preparations are known to be produced by this group of organisms. These products comprise some of our most valuable antibiotics, and new ones are being added to the list constantly.

These antibiotics possess certain peculiar properties which differentiate them sharply from ordinary antiseptics and disinfectants. They came to supplement the salvarsan of Ehrlich and Hata and the sulfa drugs of a quarter of a century later. One of the most important properties of these agents is their selective action upon different cells, be they cells of microscopic forms of life or cells of higher organisms. By utilizing this selective action, one can obtain antibiotics that are able, without injuring the tissues of a higher organism, to affect the pathogenic organisms invading such tissues. This makes possible their therapeutic use.

Ehrlich was the first to recognize that the efficacy of a chemotherapeutic agent depends upon the difference in its toxicity to the parasite and to the host. He was carried too far afield by his side-chain theory, and did not recognize clearly, largely because of a lack of sufficient information at that time, that this important difference in the action of a chemical compound is due to the variation in effect that it exerts upon the metabolism of the parasite as compared to that of the host cells. The compounds that he used were too "toxic," since they exerted their lethal effects upon the invading organism and upon the patient in about equal degrees. The finding of Woods and Fildes in 1940 that the sulfonamides exert their effect upon bacterial growth by interfering with the normal metabolism of the bacteria was a marked step forward in our understanding of the mechanisms of growth inhibition thus involved.

Many years elapsed between the discovery of the potentialities of antibiotics and their clinical application. Prior to 1939, numerous uncoordinated observations concerning the antagonistic effects of one organism upon others were to be found in the literature. Although these observations have frequently been catalogued, and the impression may thus be given that all of them have contributed directly or indirectly to the development of the science and application of antibiotics, the truth is that most such ancient observations can be properly interpreted only in the light of modern knowledge. In this respect many of them are on a par with folklore, which is pleasant to consider but which has hardly served to advance our present knowledge. Some of the observations are found in the works of men with keen scientific minds, who had too little interest to pursue the ideas further and were satisfied with speculations concerning potential significance. The observations of Roberts in 1874, of Tyndall in 1876, of Pasteur in 1877, and of the many investigators during the early part of this century, such as Frost in 1904, Vaudremer in 1912, and Gratia and Dath in 1924, remained uncoordinated, and the great practical potentialities of the phenomena involved went unrecognized.

Most of the observations of microbial antagonisms were limited to the bacteria, since these organisms were believed to be the major group of disease-producers and received the major attention of the medical bacteriologist. The contributions of Babes, Emmerich, Garré, Freudenreich, Doehle, and Kitasato appearing before 1890 are particularly important in this connection. Kitasato, for example, reported in 1889 that *Pseudomonas aeruginosa* (*Bacillus pyocyaneus*) inhibited the growth of cholera vibrio, which, in turn, had the capacity to inhibit the growth of a variety of other organisms, including *B. anthracis*. Subsequent studies, notably those on the aerobic spore-forming bacteria, which culminated in the work of Dubos in 1939, enlarged greatly upon this concept.

Students of mixed populations in soils and in water basins, as well as plant pathologists, also frequently observed the repression of one group of microorganisms by another. Their attention was directed primarily to the fungi in their relation to bacteria and to one another. These studies resulted in some rather striking observations, the complete elucidation of which had to wait for many decades. They culminated in the isolation of chemical compounds that were responsible for the growth-inhibiting effects. Thus, in 1896, Gosio isolated an antibacterial substance, designated as mycophenolic acid, from a species of *Penicillium*. In 1913, Alsberg and Black isolated penicillic acid from another species of *Penicillium*. Fleming, in 1929, isolated penicillin from still another species of this genus. Weindling isolated gliotoxin in 1932–34 from species of *Gliocladium* and *Trichoderma*.

The actinomycetes received the least attention, although in 1925 Gratia described mycolysate produced by a *Streptothrix*, and Russian investigators described actinomyces lysozyme. It was the bacterial products that received the greatest consideration. The pyocyaneus and fluorescens groups among the gram-negative bacteria gave pyocyanase, pyocyanin, and a host of other preparations. The spore-forming bacteria yielded sentocym and a variety of other products. Some of these were considered as lipids and others as proteins.

All these investigations remained uncoordinated and hardly pointed to a new broad field of science and application. A synthesis was required. This was brought about in 1939–40, when three series of investigations, one influenced to some extent by the other, but each dealing with specific groups of microorganisms, resulted in outlining clearly the new field of antibiotics. These made possible broad generalizations concerning a new concept in microbiology, which laid the basis for the wide developments in the field.

The microorganisms considered as potential producers of antimicrobial substances were the spore-forming bacteria, fungi, and actinomycetes. It is of particular interest to note, from a historical point of view, that these organisms remain even at this moment the most important producers of antibiotics, although not necessarily in the order given here.

1. *Spore-forming Bacteria*. Dubos established, in 1932, that the soil harbors certain spore-forming bacteria that are capable of producing enzymes that hydrolyze the capsular carbohydrate of the pneumococcus. This suggested a possible new approach to the treatment of pneumonia. He then proceeded with the study of the occurrence in the soil of organisms that had the capacity to produce chemical substances which would destroy bacteria as a whole and not merely attack specific chemical constituents of the bacteria. Having been trained in the field of soil microbiology, he utilized one of its classical methods, which consisted of enriching the soil with specific materials to facilitate the isolation of organisms that have a particular effect upon such materials. He utilized this method in the successful isolation of the organism which produced the capsular carbohydrate-splitting enzyme. He next enriched the soil with living bacteria. After numerous enrichments, which lasted two years, he succeeded, in 1939, in isolating from the soil a spore-forming bacterium (*B. brevis*) which produced a group of compounds (polypeptides in nature) that had a destructive effect upon gram-positive bacteria. He designated the first substance thus isolated as gramicidin and the group of polypeptides as tyrothricin. The latter was active against various bacteria not only in vitro but also in vivo. Although it was somewhat toxic and possessed certain other limitations, such as a narrow antibiotic spectrum, it exerted a marked therapeutic effect in experimental animals. Thus the basis was laid for a new approach to the isolation of a type of chemical compound which could be used in the treatment of infectious diseases.

2. *The Rediscovery of Penicillin*. After Fleming demonstrated in 1929 that certain preparations obtained from cultures of *Penicillium notatum* and designated as penicillin possessed antibacterial properties, several attempts were made to isolate the active substance in a purified state. Its great potential usefulness for the control of infectious diseases was not recognized until 1940, when Florey and Chain at Oxford, stimulated by their interest

in lysozyme, decided to investigate various molds for their ability to produce lysozymelike substances. They turned their attention first to the *Penicillium* studied by Fleming. Not only did they succeed in producing penicillin in the culture broth and in isolating a very active preparation, but they also established its very low toxicity and great effectiveness in the treatment of human and animal diseases. These results served to focus immediate attention upon the great therapeutic potentialities of microbial products, notably those of molds, and heralded another period of the new era in chemotherapy.

3. *Actinomycetes as Antibiotic-producing Organisms.* Although the bacteria have now yielded several antibiotics which have assumed an important place in human and animal therapy, and although the molds have contributed penicillin—probably the most valuable antibiotic so far discovered—it is the actinomycetes that have given to the medical profession the largest number of effective antibiotics. This group of organisms is still leading the field of research as potential producers of new antibiotics possessing antibacterial, antifungal, antiviral, and antitumor properties. It is of further interest to note here that although before 1939 much was known of bacterial products possessing antimicrobial properties, as pointed out previously, and although a number of active products produced by fungi were obtained as crude preparations and were isolated and crystallized, very little was known of the antibiotics of actinomycetes.

A systematic study of these organisms was begun in 1939, in the Department of Microbiology of Rutgers University. The first antibiotic isolated in 1940 was actinomycin. This was followed by streptothricin in 1942, and by streptomycin in 1943. These discoveries laid the foundation for still another phase of antibiotic research, the end of which is not yet in sight.

The Period of Accomplishment

What has been accomplished since 1940, or in this brief period of about twelve years? One could hardly be accused of undue optimism or of excessive generalization if one were to say: A great deal. A new field of science has been opened up. The pharmaceutical industry has undergone tremendous change: It is said that at least 50 per cent of all drugs sold over pharmacy counters, in the United States at least, consist of or contain antibiotics. Medical practice has been revolutionized: Many diseases that appeared to be beyond control only a decade or so ago have now become innocuous, and some have been virtually eliminated. The fear of great epidemics, such as those of plague and cholera, of typhoid and typhus fever, of pneumonia and a great variety of other infections, has either been eliminated or greatly reduced. Even tuberculosis, the Great White Plague of man, is now about to be brought under control. Diseases of childhood no longer breed the fear they once bred: The antibiotics have brought about their complete or virtual elimination. Who could dream of such potentialities a mere dozen years ago?

To be sure, other diseases have come to the front, especially virus diseases, neoplastic diseases, many fungus diseases, and the numerous physiological and psychological diseases associated with old age and with our present mode of life. But with the advent of the antibiotics, even these diseases no longer produce the dreadful spectra of fear which faced the human race only a few years ago, and there is hope that these as well will sooner or later be brought under control.

Penicillin is now used successfully in the treatment of syphilis and of diseases caused by gram-positive bacteria. Streptomycin is used in the control of many of the diseases caused by gram-positive bacteria that have become resistant to penicillin, as well as diseases caused by gram-negative bacteria, and of tuberculosis. Chloramphenicol, aureomycin, and terramycin are used effectively in the control of rickettsial diseases, typhoid, and a variety of other diseases that are either not sensitive to penicillin and to streptomycin or have become resistant to both these antibiotics. Tyrothricin, bacitracin, polymyxin, neomycin, and erythromycin have come to fill the gaps among diseases which the previously mentioned antibiotics do not affect or for which they cannot be used for various reasons.

There are numerous other fields of importance to human and animal health, or to human economy, in which the antibiotics have found or are finding important applications. Only a few need be mentioned here: the successful treatment with antibiotics of many animal diseases and of a few plant diseases; the use of antibiotics in the feeding of nonruminant animals; the use of antibiotics in the preservation of biological material, such as bull semen and virus preparations.

One may look with pride and wonderment at the great accomplishments in this very brief period.

What About Tuberculosis?

Not so long ago—even after the sulfa drugs had been introduced as chemotherapeutic agents and the potentialities of penicillin for combating a vari-

ety of infections had gradually been unwrapped before the eyes of the amazed world—the prevailing opinion was that no chemotherapeutic agent significantly effective in the treatment of tuberculosis would ever be discovered. Only about eight years have elapsed since a leading authority in the field said to me: "Perhaps all diseases of man may sooner or later become subject to therapy, through the use either of synthetic compounds or of antibiotics, but tuberculosis alone will resist all such efforts; it will remain with us, and its treatment will have to continue to depend upon bed rest, proper nutrition, and other old-time remedies." Meanwhile, streptomycin has revolutionized the medical approach to this disease. At first, this antibiotic was used alone; later it was supplemented with PAS. More recently, the introduction of isoniazid points to a complete change in the mode of treatment of various forms of tuberculosis. Thus, the introduction of antibiotics and synthetic compounds has placed in the hands of the medical profession powerful tools for combating tuberculosis.

I can do no better than cite from two recent reports. One from Great Britain[11] states:

> Whatever the ultimate picture may be, it is clear that chemotherapy has given us a big new advantage over the old adversary. Just as anaesthetics cleared the way for the surgeon by giving him time for careful and intricate work, so the new drugs have given chest physicians and surgeons time to consider the next move and develop new techniques. Their influence on the rate of decline in mortality is apparent, though the acceleration may not be maintained if the effect of the new drugs is merely to prolong life for a few years.

Another from the United States[12] emphasizes:

> Isoniazid and streptomycin both rank high as antimicrobial drugs in terms of such attributes as ability to interfere with vital activities of a parasite, distribution and maintenance of activity within mammalian hosts, and reasonable toleration on long-continued administration. Both substances compare very favorably with the antimicrobial drugs used in the treatment of other infections. The limitations on what may be accomplished by isoniazid and streptomycin in pulmonary tuberculosis arise not from any special lack of effectiveness on their part as drugs but from the nature of pulmonary tuberculosis with its destructive component.

What of the Future?

Antibiotics are so new that numerous problems still remain unsolved. Among the most puzzling is their mode of action. There is no doubt that the action varies with each type of antibiotic; otherwise all would act alike. Aside from different degrees of toxicity, which may depend upon differences in the chemical nature of the materials, one is justified in asking: Why is one antibiotic active against certain types of organisms and not against others? The most important substances chemotherapeutically, such as penicillin, streptomycin, aureomycin, chloramphenicol, terramycin, neomycin, bacitracin, and polymyxin, are active upon certain bacteria and actinomycetes, but not upon fungi. On the other hand, some of the other antibiotics, like fradicin, actidione, fungicidin, and candicidin, are active upon filamentous or yeastlike fungi, but not upon bacteria and actinomycetes. Still others, like actinomycin, clavacin, and streptothricin, are active upon bacteria and actinomycetes and also upon fungi, with great variations between the individual species and even strains. The antiviral agents, such as ehrlichin and abikomycin, are even more specific: they are active upon certain viruses, but not upon fungi and bacteria.

Why should an organism develop resistance to an antibiotic to which it was originally sensitive? Why should certain organisms become dependent for their growth upon a particular antibiotic? What is the relation between the chemical structure of the antibiotics and their mode of action? Fortunately, an organism that has developed resistance to one antibiotic still remains sensitive to others. This and the fact that more than one antibiotic is now available for the treatment of most types of infectious diseases render the above questions largely of theoretical rather than of immediate practical importance.

The great majority of infectious diseases caused by bacteria and actinomycetes are now subject to therapy by antibiotics and various synthetic compounds. The existence of a large number of antibiotics active upon fungi makes one feel fairly certain that these organisms likewise will soon come under control. Further, the protozoan and insect diseases appear to be well taken care of by various synthetic chemical agents, such as arsenicals, plasmoquine and paludrine, atabrine, DDT, and the like. The main problems that remain, aside from the purely physiological conditions, are concerned primarily with virus and neoplastic diseases. Here again one may feel hopeful, although it is difficult to foretell the exact time when these diseases can be attacked by antibiotics and other chemotherapeutic agents.

Conclusions

The two approaches to microbiology opened by Pasteur and continued so successfully by Koch, Kitasato, Behring, and others, on the one hand, and by Ehrlich, Domagk, Trefouel, and finally by the discoverers of the antibiotics, on the other, have

greatly enriched human society. They have served, first, to provide an understanding of, then to eradicate, the infectious diseases of man and his domesticated plants and animals. Let us hope that they will finally serve to create a better, richer, and more healthful world in which to live.

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HOW CAN YOU SAY?

How can you say,
You thinking ones
Who live upon a
Space-borne orb,
Whether beautiful
Long strands
Of seaweed
Grow upward
From land slid under sea,
Or hang
From blue-bayed rocky ledges
Downward
Toward that other blue
Of sky?

Is granite-terraced
Green-wooded
Shipstern Island
A pendant tourmaline
Hung on a chain
Of surf and spindrift?
And snow but
Vapor-stars
Rising to a waiting
Earthly paradise?

RACHAEL GRAHAM

Harrington, Maine

Early American Geology*

GEORGE W. WHITE

Until he went back to his native Ohio as professor of geology at Ohio State in 1941, George White had spent most of his academic career at the University of New Hampshire, which may account for his interest in the early history of geology in the United States. He left his alma mater (Ph.D., 1933) in 1947, to become head of the staff of the Department of Geology, University of Illinois.

THE early English voyagers sailed to America with certain information about the new continent, its aspect, and its resources. At first the information was vague and partly erroneous, and some of it was fantastic. They modified, amended, and added to the slim store of recorded facts on topography and mineral resources as Thomas Hariot[1] did so significantly in 1588.

After the first period of exploration, when actual settlement had begun, information which included geological data, both exact and inexact, was compiled for those in England contemplating settling in the new land—as, for example, by John Smith in his several works from 1608 to 1631, and by William Wood in *New Englands Prospect* in 1634.

After the settlements were well established, men of taste, thought, and observation commented on natural phenomena—including geological features—quite as penetratingly as their English cousins were doing in the late seventeeth and eighteenth centuries. A surprising number of the colonists were members of the Royal Society; one was a charter member.[2] Some of the American geological observations and theories, such as that on isostasy by Lewis Evans in 1743,[3] were fully as advanced as English ones of the same period.

This long period of geological observation, first by English visitors, but soon by colonial Americans, has been strangely neglected by historians of science and by historians of geology. Goode[4] discusses at length early biclogical observations; Osborn[5] and Simpson[6] have noted early observations on vertebrate fossils. The historians of geology from the time of the early outlines of the development of geology in America by Van Rensselaer[7] and Mather[8] to Merrill[9, 10] all agree that the beginning of geology in America was early in the nineteenth century and that William Maclure was its father. Samuel L. Mitchill is mentioned for his work of the same period, but the first book devoted entirely to American geology, that by Schoepf in 1787[11] is given cnly the barest mention. These early workers of the "Maclurean epoch," important as they certainly are, did not invent American geology out of thin air, or discover it in a vacuum. For more than two hundred years before 1800 facts had been accumulating upon which, in some cases, respectable theories had been constructed. It is my purpose to sketch the expanding knowledge of geologic fact recorded in English concerning the American colonies, and to cite examples from each of the colonial centuries.

The Earliest Voyagers and their Information

We actually know very little about the observations of John Cabot in his voyages to Newfoundland in 1497, but he is reported to have observed copper in possession of the natives.[12] Hakluyt in 1582[13] gave an English translation of the report of Giovanni de Verrazano of his sailing along the North Atlantic coast in 1524, in which copper possessed by the natives was noticed. As the reports of these voyages did not contain information on rich minerals, it is of interest to note just where the epic English voyagers of the late sixteenth and early seventeenth centuries—Frobisher, Gilbert, Lane, Grenville, Brereton, and Smith—did get their information about natural conditions, metals, and other products and their high hope of rich mineral resources.

Richard Eden[14] in 1555 brought together and translated a miscellany of travels by Peter Martyr, Oviedo, and others, and part of Biringuccio's book on metallurgy of precious metals, under the title of *The Decades of the New World*. Eden obviously is presenting the e earlier reports on the richness of the New World in such a way as to encourage English expeditions and the support of such undertakings by those who could invest "venture capital."

Peter Martyr, as translated by Eden, refers to gold on almost every page by pounds, by tens of pounds, and by hundreds of pounds. Oviedo in his

* Address of the retiring vice president and chairman, Section E, AAAS, at St. Louis, December 29, 1952.

"Generall [natural] historie of the West Indies," which in Eden's compilation follows Martyr's work, begins with a very lucid description of placer gold mining, and makes it clear that the gold has come from veins ("mother lodes") in the mountains at the headwaters of the streams. Among other minerals described is bitumen used for caulking ships in Cuba and in other islands (Trinidad?), in what may be the earliest note on hydrocarbons in the New World and is almost certainly the first in English.

Oviedo tells of one "grayne [nugget] of golde of great weight" weighing 32 pounds, another of 7, and another of 5 pounds. He comments on a large amount of gold in other places; his detailed description of the golden armor of the Indians and of the "principall women" who wore brassieres of golden bars weighing more than 200 ducats must have fired the imagination of the English would-be voyagers. Eden's book of 1555 and the revision by Willis in 1577 were sources of information and of exciting stimulation to the English. When we realize the quarts of pearls, pounds of gold, and quantities of golden armor and lingerie the English expected to find, we can visualize their great disappointment when they found the Indians of Virginia and New England not only with no golden raiment, but without any armor or brassieres at all.

The Frenchman Jacques LeMoyne, reporting on the Laudonniere expedition to Florida in 1564–65 tells of the (placer) gold mining in the "Apalatcy Mountains" and painted a picture of this mining activity, an engraving of which was printed in 1591 by DeBry.[15] This appears to be the first picture of any part of the United States having to do with anything geological.

The "Minerall Men"

The personnel of the English expeditions of the latter part of the sixteenth and early part of the seventeenth centuries included economic geologists and mining and metallurgical experts. Some were English (Cornish?) and others were Germans; they are referred to as "minerall men" or "refiners." We even know the names of some of them: Captain Vaughan with Grenville, Lane, and Hariot; the Saxon Daniel with Sir Humphrey Gilbert; and William Callicut, William Dawson, and Abraham Ransacke, plus two goldsmiths with Captain John Smith. Frobisher, who explored in 1576–78 north of the present United States, appears to have had more than one such expert. They were of various abilities, even as present-day "minerall men."

Recent critical editions and translations of the sixteenth-century works of the mining geologist and engineer Agricola,[16] the metallurgist Biringuccio,[17] the assayer Ercker,[18] and the assayers of the *Probierbüchlein*[19] make it easier for us to examine the kind of knowledge that could have been available to the mineral men and to those others who had interest in metals and their ores in the New World. It is certain that not all the voyagers were equipped with even a small part of this knowledge, but the professional "minerall men" should have had at least a part of it. (Note, however, the repeated complaint of Captain John Smith about the ineptness of his mineral experts.)

Early Observations in Virginia

THOMAS HARIOT (1560–1621). Thomas Hariot's *A briefe and true report on the new found land of Virginia* of 1588[1] is the earliest publication on natural history of what is now the United States.[1, 20, 21] Biologists have heard of his accurate and lively observations on plants and animals, but geologists have only recently known of his considerable and respectable geologic observations.[22]

Hariot accompanied the Raleigh expedition of 1585 to Virginia (North Carolina) as historian, scientist, and adviser. Upon his return to England in 1586 he prepared the report which was published in 1588 and which is now one of the rarest and most desirable of Americana. In his list of "Marchantable commodities" Hariot mentions several minerals, including alum, and notes the occurrence of iron and copper. His observations are confirmed in the report of the governor, Ralph Lane,[23] who tells of the concurring opinion of Captain Vaughan, "minerall man" of the party.

In his "Conclusion" Hariot gives the first description of the changing character of the Coastal Plain toward the Piedmont. We are impressed by his geological knowledge when we summarize what Hariot knew from personal observation and actual experiment about the geology of Virginia:

1. There was a wide flat coastal region (Coastal Plain) without prominent stones.
2. Along a distinct line (Fall Line) hard (crystalline) rocks appeared and continued an unknown distance into the country (the Piedmont).
3. The character of the crystalline rock varied.
4. The rocky ground at places contained iron, which he had seen and knew on professional advice to be ore.
5. Copper occurred someplace beyond the limit of exploration but supposedly not far away. The material was positively copper on the basis of its melting character.
6. The copper was silver-bearing, as determined by assay by Hariot and the "minerall man."
7. Excellent and plentiful clay for brick making existed in the Coastal Plain.

8. The fossil shells in the Coastal Plain sediments may have been recognized as remains of actual organisms. We know, from other sources, of Hariot's interest in fossils.[24]

JOHN BRERETON (fl. 1602). After the voyages supported by Sir Walter Raleigh in 1584–91 there was little exploration by the English along the Atlantic Coast until 1607, except for that of John Brereton, who passed along the New England Coast in 1602, and the same year published a little book on his "discoverie."[25] Brereton's observations on natural history consist mainly of those on minerals and topography of southern New England, Martha's Vineyard, and Nantucket. He was much impressed by what we today call industrial minerals—especially by building stone and clay.

CAPTAIN JOHN SMITH (1580–1631). Captain John Smith's claim to notice in any history of early American natural history[4] and in any history of early American geology rests upon the scientific and geographic observations recorded in his several books on Virginia and on New England which appeared between 1608 and 1631.

It is hard to realize that the Captain John Smith who was the actual and later the titular leader of the Jamestown colonists was in 1607 a man not yet twenty-seven years old.[26] All his incredible adventures as seaman, soldier, shipwrecked mariner, ambassador, Turkish slave, escapee, and traveler in Europe, Turkey, North Africa, and Ireland took place between his thirteenth and his twenty-fourth birthdays. When he sailed to Virginia with the settlers it was as one of those who had invested in the project and not as a hired member of the party.

From Smith's voluminous writings and his compilations of the writings of others, it appears that Smith himself was from the outset skeptical about finding precious metals or a route to the Indies. One gets the impression that he felt from the first that the future of Virginia lay in colonization and the development of trade. His attention to soil types confirms his interest in agricultural resources. Indeed, he is honest enough on one occasion to write that the hope of gold was used only to secure backing for his voyage to New England.

The principal source of information about the Virginia seen by Smith and his associates is the book[27] first published in 1612, *A Map of Virginia, with a description of the Countrey. . . .* The map, whether made by Smith or by members of his party under his direction[13, 28] is a remarkable production considering the conditions under which it was made. It is tolerably accurate geographically, shows the Indian territories and towns, and—a point I have not seen emphasized—clearly indicates which parts are based on actual exploration of the ground and which based on reports. The flat Coastal Plain is differentiated from the more hilly Piedmont. Falls are indicated where the various rivers cross the boundary from the harder rocks of the Piedmont to the softer ones of the Coastal Plain (the Fall Line).

Smith describes crystalline rock at "the head of the Bay" near Baltimore. His description of soil—probably the first one in English for America—clearly recognizes the variation of vegetation with soil types. After describing the rivers, their valleys, and their inhabitants, Smith passes on to a lengthy description of trees, fruits, plants, animals, fishes, and birds. He concludes this summary of the natural history of Virginia by a paragraph on "The Rocks":

> Concerning the entrails of the earth little can be said for certainty. There wanted good Refiners: for these that tooke upon them to have skill this way, tooke up the washings from the mounetaines and some moskered [disintegrated] shining stones and spangles which the waters brought down: . . . The crust also of these rocks would easily perswade a man to beleeve there are other mines than yron and steele, if there were but meanes and men of experience that knew the mine from spar [i.e., knew ore from worthless gangue].

Smith's lack of certainty "Concerning the entrails of the earth" is refreshingly modern; we are still uncertain about them. Smith is again contemptuously sure that the "moskered shining stones" are not gold and is disdainful of the "refiners," of whom he had three.

Captain John Smith left Virginia for England in 1609, never to return to the colony that could not have survived the rigors of the winters of 1607 and 1608 without his guidance. After several years in England, during which he wrote his famous book on Virginia and defended himself from the charges of his enemies, he returned to British America, this time to a more northeasterly part of it. Smith briefly explored the New England shore in 1614, but his return in 1615 was prevented by storms and his capture by the French. Quite characteristically, during his captivity and upon his return he wrote a book: *A Description of New England . . .*,[29] in the first page of which he names New England for the first time. He contrasts the rocky coast of Maine with the sandy shores of Massachusetts, and generalizes on mineral resources.

The description of the geography and natural history of New England is not quite so smoothly organized as the earlier one of Virginia, but nevertheless is full of information. He apparently did not have an assayer ("minerall man" or "refiner") along

on this voyage to New England, but acted as his own assayer. Again the common attitude "there must be gold in them thar hills" is expressed by Smith, although we get the impression he himself did not really believe it. Always one to emphasize the more immediate and known resources, such as fish and furs, he knew at firsthand about iron ore and how important it could be to a new colony.

John Smith—soldier, sailor, explorer, administrator, colonizer, writer—was less credulous than most; he realized that in America the English had a world for settlement as well as for exploitation of any precious metals. In contrast to fertile soil and fundamental resources of iron and fuel to smelt it, he felt that precious metals were unimportant. He had the keen eye of the successful soldier for topography, but not the scholar's contemplative consideration of its continuity and origin, as had Hariot. He had the scientific spirit of true report of data, but left to others analysis and theory.

Observations in New England

WILLIAM WOOD (fl. 1629–39). William Wood, in his famous 1634 description,[30] *New Englands Prospect*, devotes Chapter 4 to "the nature of the Soyle," which he says "is for the generall a warme Kinde of earth," and after describing meadows and hay crops, tells of soil derived from clay, sand, and gravel.

Wood did not take "great notice" of "commodities as lie underground," and gives scant space to meager secondary material on minerals. The attitude toward precious metal had changed markedly in the twenty-five years since the settlement of Jamestown, when the settlers, fired by the tales of Martyr and Oviedo as translated by Eden, expected to find gold and silver at every bend in the rivers. Now, although he asserts that precious metals may yet be discovered in the "barren mountaines," Wood says "nobody dare confidently conclude" that they are present. The New Englanders had turned to more obvious resources—slate, building stone, and clay for bricks—which were to be of real use for their comfort.

Wood had considerable firsthand information of water supply and discusses in a fascinating manner the quality of water. His remarks on water supply are the earliest in America so far known to me. He comments in detail on the ease of finding wells and asserts that the quality of the water is so superlative that it is almost as good as "good Beere" and that "any man will choose it before bad Beere, wheay, or Buttermilk."

THOMAS MORTON (d. 1646). Thomas Morton was a man who flaunted his impertinent actions before his Puritan neighbors and satirized them in his book *New English Canaan*.[31] His book, published in 1637, makes clear his high approval of the country and the Indians, but also—and not guardedly—his disapproval of the Puritan settlers.

Morton's contribution is more to our amusement than to our geological knowledge. Slight though his geological observations were, his book does show that some minerals were known, and that industrial minerals—lime, whetstones, and building stones—were coming into use.

He notes the excellent supply of ground water and tells of the ease of digging satisfactory wells. He overestimates the curative value of certain medicinal waters, but in so broad a way that there is little doubt he does so facetiously.

JOHN JOSSELYN (fl. 1630–75). Over the next forty years about a dozen publications contain material on American natural history and include geological and topographic observations. Among these is *New Englands rarities discovered . . .*, by John Josselyn,[32] in 1672. He describes the White Mountains and the topography of Mount Washington in considerable detail, especially the valleys cut into that mountain. He ascribes at least part of the cutting of these "Gullies" to running water, the first record I have found of such assumption in the New World.

Josselyn's chapter on "Stones, Minerals, Metals, and Earths" is disappointing in its brevity, merely listing several kinds of clay, metal ores, and gems (two of them mistakenly identified). The concluding paragraph of the mineral chapter on a strange cure for cancer is as out of context as it is startling.

JOHN CLAYTON (fl. 1688–93). About twenty years later John Clayton in 1693 wrote in the *Philosophical Transactions* on several American natural history subjects.[33] He also was impressed with the excellent ground-water resources of Virginia. He says that the waters in the springs are "somewhat more eager" than those in England and require "some quantity more of malt to make strong beer."

Clayton's observations on both invertebrate and vertebrate fossils in Virginia and Maryland are the equal of those across the Atlantic and were quoted approvingly in England.[34] He describes the concentration of fossil oysters in certain strata, and their association with huge teeth (shark's teeth). His description of a fossil whale is noteworthy. Clayton says the shells may be remains of animals or may be figured stones, exactly the attitude of Ray, Lister, and Lhwyd, who at this time described English fos-

sils at length, but could not bring themselves to decide their origin.[35, 36]

First Half of the Eighteenth Century

ROBERT BEVERLEY (1673?–1722). Robert Beverley, the Virginia planter, was the first native American to write on Virginia.[37] In 1705 he published *History and present State of Virginia* in which he tells of the expedition of Captain Henry Batt to the Appalachian Mountains. There appears in this record a suggestion of the recognition of the parallel ridges of the folded Appalachians, the wide valleys between the ridges, and of the Appalachian Plateau, where a "Rivulet descended backwards."

In the chapter "Of the Earths, and Soil," Beverley shows a keen discrimination of soil varieties based on parent material—clay, sand, gravel, stones, or marl; and on topographic situation—lowland or upland. He is particularly specific in his references to the various shrubs and trees that grow on the different soils.

He is thorough in his listing of several varieties of clay and pigments, and mentions coal, slate, and building stone. He differentiates between Coastal Plain and Piedmont, and contrasts the region of "lower parts," flat, and free from stones (Coastal Plain) with the higher country where, especially near the "Falls of the Rivers," are found "vast quantities of Stone." He recognizes the continuity of the regular boundary between the Coastal Plain and Piedmont, and indicates that the Piedmont gives way farther west to mountains.

Beverley's reference to Colonel Byrd's exploration for the extension and reopening of the iron mine at Falling Creek by "boring, and searching after the richest Veins, near the Place of the former Work" is almost certainly the first record of exploratory drilling in America.

Beverley's sense of appreciation of amount and quality of water supply is repeatedly evident. His consciousness of rivers for navigation and springs for water supply and mills reflects his needs as a planter with large interests and operations. He also knows of "several Mineral Springs" but only briefly describes them, for he says he is "not Naturalist skilful enough, to describe them with the Exactness they deserve."

His account is a valuable one because it tells us what an educated man of 1705 knew of the topography and geology of Virginia. There is no speculation about causes or origins, but we are glad to have his literate and pleasant observations.

JOHN BARTRAM (1699–1777) and PETER KALM (1716–1779). At least 40 more books and papers on natural history were written in the next fifty years. The quality and amount of geologic observation vary, but the bulk is considerable. These must be passed over, for reasons of time and space, to discuss the observations and publications of three men who show great advance, not only in observation, but also in synthesizing data and proposing explanations. It is difficult to understand how their work has been neglected, for it provided a foundation—both acknowledged and unacknowledged—for those better-known men who followed.

These three are John Bartram, Philadelphia botanist and natural historian; Peter Kalm, Swedish traveler and scientist; and Lewis Evans, surveyor, cartographer, and geologic observer. Bartram's book on natural history of 1751[38] describes topography, rocks, fossils, and raised beaches near Lake Ontario. Of Kalm's several publications, the chief is the account of his travels first published in Swedish in 1753, in English in 1770, and available in a recent translation.[39] His more than 150 excellent geological observations and interesting speculations aggregate tens of pages and cannot be discussed adequately in a short space. It should be noted, however, that he speculates that Ireland and North America were once either united or else an island chain existed between them. He repeatedly mentions erratics and at one place till, but does not theorize on their origin.

LEWIS EVANS (1700–56). Lewis Evans' work[40] will serve as an example of the very respectable American geologic knowledge of the middle of the eighteenth century. Evans was born in Wales in 1700, but his entire professional career as surveyor, cartographer, and pamphleteer was spent in America.[41]

Evans traveled widely and observed acutely. In 1743 he made a trip from Philadelphia to Onondaga and Lake Ontario in the company of John Bartram and Conrad Weiser, interpreter and ambassador to the Indians. Evans carefully recorded his observations in a journal,[42] from which we note his certainty that fossil shells are remains of marine organisms, his recognition of the exhumation of the present Appalachian ridges from a former plain (peneplain!), the erosion of valleys to leave mountains, the linear character of the Appalachian ridges, the Coastal Plain, the former greater extent of the Great Lakes, and the isostatic uplift consequent on unloading the earth's crust by partial draining of the lakes.

Evans' maps[43] of Pennsylvania and adjacent states are very rare, but facsimiles are now available.[44] In these maps Evans filled in blank spaces

with notes on weather, roads, streams, and geology. His "Remarks on the Endless [Appalachian] Mountains, etc." are excellent geologic descriptions.

The 1755 Evans' *Map of the Middle British Colonies*[44] is so full of geographic data that, except for spot indication of "Coals" and "Freestone," all geologic notes are presented in a separate booklet of 36 pages: *An analysis of a general map of the Middle British Colonies*.[43] In the preface Evans regrets not being able to include on the map profiles and geologic sections, stating:

> But Want of Room in the Plate, has obliged me to leave out what would have very much assisted my Explanation of the Face of the Country, I mean a Section of it in several Directions: such would have exhibited the Rising and Falling of the Ground, and how elevated above the Surface of the Sea: what Parts are level, what rugged: where the Mountains rise and how far they spread. Nor is this all that a perpendicular Section might be made to represent: for, as on the upper Side, the Elevations, Depressions, outer Appearances and Names of Places may be laid down: on the lower, the Nature of the Soil, Substrata and particular Fossils may be exprest. It was with Regret I was obliged to omit it. But in some future Maps of Separate Colonies, I hope to be furnished with more Room.

We share Evans' regret for the omission, for it was more than fifty years before Maclure[46] presented geologic sections, and these did not show all the features Evans proposed to include had there not been "Want of Room in the Plate." Neither these sections, nor "Maps of the Separate Colonies," were published, for Evans died under tragic circumstances the following year.

In the *Analysis* is a clear statement of the physiographic and geologic provinces of the eastern United States.[47] It is the first attempt at delineating physiographic provinces of the whole country and is valid today. Although his description of New England is brief, for the country west of the Hudson he describes in very considerable detail what we now call the Coastal Plain, the Fall Line, the Piedmont Plateau, the Blue Ridge, the Folded Appalachians, the Allegheny Front, and the Allegheny Plateau.

Evans deserves an important place in the history of American geology because of his maps with their geological notes; his *Analysis* with geological descriptions; and his journal, with theories on Great Lakes drainage, isostasy, and stream origin. He is perhaps equally important because he furnished additional geological information to his contemporaries John Bartram, Kalm, and others.

We can trace Evans' geologic contributions for sixty years after his death. Kalm widely disseminated them. Books of travels display knowledge of them as, for example, that of J. F. D. Smyth.[48] The idea of deposition of sedimentary rock and fossils in inland bodies of water, often attributed to Volney[49] and to Mitchill,[50] who developed the concept in great detail, traces back to Evans.

It is unfortunate that Evans did not live to publish the planned maps of separate colonies with geologic cross sections. If he had done so his just place in the history of American geology would have been earlier recognized.

Last Half of the Eighteenth Century

It is necessary to pass over many other men of the eighteenth century who contributed geological observations, descriptions, and even hypotheses, for their consideration would require a lengthy paper in itself. We can only note that more or less extensive geologic references are to be found in the writings of John Winthrop (Hollis professor at Harvard), Benjamin Franklin and several of his circle, William Bartram, Peter Collison, Jonathan Carver, Thomas Hutchins, Thomas Jefferson, Jeremy Belknap, Thomas Pownall, and many others. I pass over the first geological map of North America by Jean Ettienne Guettard in 1752[51] because it was made by a man who was never on this continent, but who compiled his map from information from French correspondents.

The extensive observations in 1784 of the very little-known J. F. D. Smyth[48] occur in a two-volume book of travels. In addition to describing the Appalachian and Cumberland mountains he pays much attention to waters, streams, and valleys, noting in detail natural levees in some of the valleys.

The two-volume travel book[52] of 1787 by the philosopher-soldier François Jean, Marquis de Chastellux (1734–88), second in command of the French forces in the Revolution, provides unexpectedly rich geologic references. His approach is genetic, and he seeks and proposes many clever explanations to account for geologic phenomena. He is not the first to notice erratics, but he is the first I have found who speculates on their origin; although he could produce no hypothesis that satisfied him, he was thoroughly aware of the problem.

The first book entirely devoted to the geology of the United States is by the Hessian physician Johann David Schoepf (1752–1800) in 1787.[11] Much of the material in it is included in a more general travel book published the next year.[53]

With the mention of Schoepf we make contact with already known history of American geology. In the first decade of the nineteenth century appeared the works of Maclure,[46] Mitchill, Cleave-

land,[34] and others with whose names we are at last familiar,[9] and my project of pointing out the hitherto unsuspected colonial interest in, and knowledge of, geologic phenomena comes to an end. Before 1800 the scores of publications by more than 40 different men contain important geological descriptions and observations, and include respectable hypotheses. A list of the first observations of various phenomena or of first proposal of concepts may provide a useful summary (Table 1).

TABLE 1

1524	First reference to copper—Verrazano
1588	First book on natural history and geology—Hariot
1591	First picture of mining (Appalachian region)—DeBry from LeMoyne
1612	First maps differentiating Piedmont from Coastal Plain—John Smith
1612	First description of soil types—John Smith
1634	First ground-water report—Wood
1672	First recognition of valley cutting by water—Josselyn
1705	First exploratory drilling—Byrd
1705	Physiographic description of Virginia and ground-water report—Beverley
1743	Great Lakes more extensive (shown by beach ridges) and isostatic rebound on their draining—Evans
1752	First geologic map of any part of the United States—Guettard
1753	Land bridge from North America to Europe—Kalm
1753	First mention of erratics—Kalm
1755	First division of America into physiographic provinces—Evans
1784	Description of natural levees—J. F. D. Smyth
1787	Speculation on origin of erratics—Chastellux
1787	First book on geology of United States—Schoepf

While recognizing the importance of the early nineteenth-century work of Maclure, Cleaveland, Mitchill, and their contemporaries, we must realize that these men really had a very considerable foundation of earlier observation and hypothesis upon which to build.

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COELACANTH

Heavy with centuries, vastly unaware
Its future had been prisoned in its past;
Caught like the simple fishes, in a snare
Of Time, but uncondemned except to last;
Weary with waiting for it knew not what,
Its destiny entangled with its doom
So that it had to die to live—it cut
The ties that held it safe within the gloom.

It rose, but gave the rising little thought
And mused on other trivia instead,
Though least, on mere survival. Then it fought
And threshed about, was beaten, and was dead.

The ages are bereaved but must not weep
For, weeping, they would drown the world in tears
While we invoke formaldehyde to keep
What nature kept 300,000,000 years.

MILTON BRACKER

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Caste Determination in the Social Hymenoptera*

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TEN years ago, S. F. Light, of the University of California, in a paper entitled "The Determination of the Castes of Social Insects,"[1] reviewed and analyzed the recorded observations and experiments on caste determination in the termites and in the social Hymenoptera. He concluded that, except for the honeybee, the data obtained were inconclusive, being meager and statistical in nature. He pointed out, however, that such data as had been obtained during the period since 1928 tended to indicate that the causal factors were somatic rather than genetic. In the social Hymenoptera the demonstrated capacity of the queen under certain environmental conditions to repeat a production sequence of workers, males, and queens[2, 3] indicates that the determination of such castes is subject to environmental control.

It is well known that all honeybees developing from fertilized eggs possess the complete genic complex that would permit them to develop into either one of the female castes, and today it is generally assumed that this is likely to be the case in other social Hymenoptera, the structural, physiological, and behavioristic peculiarities of the worker caste being phenotypic deviations from the original female genotype. The general problem presented by the polymorphism of social insects is, therefore, as stated by Light, the nature of the mechanism which functions in each generation of each species to cause the offspring of the same parent to develop into different types of individuals in relatively constant numbers.

It appears from the studies of Haydak[4] and others that the factor initiating caste in the social Hymenoptera is the undernourishment or inanition of the individual during its development. The problem thus resolves itself into one of ascertaining the period in development at which inanition occurs, and the means by which it is accomplished.

Haydak's and Light's reviews of the problem of caste formation came to my attention at a time when, as a result of studies on ovisorption in parasitic Hymenoptera,[5] I had concluded that the regression of the ripe ovarian egg and its absorption into the blood stream are essential factors in the reproductive economy of all hymenopterous species in which ovigenesis is more or less continuous throughout the life of the female, and in which ovulation is externally induced.[6] It was inevitable, therefore, that ovisorption should be given consideration as a mechanism that would permit the determination of caste during embryonic development. Such a mechanism would provide a means of reconciling the divergent views of Emery and Forel[7] regarding caste determination in ants, since the undernourishment of the individual is as likely to occur in the egg stage as it is in the larval stage.

Limiting Factors in Caste Determination

In most social Hymenoptera the eggs develop into males if unfertilized, and the male sex is lacking in castes. This lack may or may not be genetic, but in certain nonsocial Hymenoptera (*Melittobia*) trophic polymorphism of both sexes does occur. It is quite possible, therefore, that the capacity to produce the male caste may be inherent in the social Hymenoptera but not realized, the developing male not being subjected to undernourishment. The fact that in many if not all Hymenoptera the ovarian eggs of the individual female apparently develop consecutively and gradually up to a certain size indicates that it is very unlikely that significant nutrient differences occur in such eggs prior to ripening.

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Except in certain bees, and possibly certain wasps, the castes apparently are not determined after egg deposition, since in no species is there any evidence that the workers which nurse and feed the developing larvae possess the inherent capacity to provide a certain amount or quality of food to particular female larvae. The production of workers and queens does not appear to be the result of discriminate biased feeding. This is evident with the ant *Oecophylla longinoda*, in which eggs deposited by the worker develop into queens, workers, and males, whereas those deposited by the queen develop only into workers and males.[8] It is significant that the differential feeding of the female larvae of the honeybee is entirely an effect of differences in the size of the cells occupied by such larvae. In the chalcid *Melittobia*, differential feeding is the result of the fact that the feeding of numerous larvae is limited to an individual host, the nutritional quality of which changes during such feeding. The absence in many ant species of a stereotyped structure or situation to ensure differential feeding is therefore strongly indicative of prelarval caste determination, a time of determination which receives support from the numerical dominance of workers in all nonparasitic ants, regardless of the wide variation in the larval nutrition of the various species.

In the social Hymenoptera it is obvious that caste control is closely correlated with sex control. It is known that the sex of the individual is environmentally determined. Sex determination usually occurs during the process of oviposition, the unfertilized egg developing into a male, the fertilized egg into a female, the utilization of the sperm being a function of the environment.[9] Since caste formation is limited to individuals from fertilized eggs, it is logical to assume that the situation that initiates the fertilization of the egg also initiates caste formation. This assumption seems to be verified by the existence of the needed mechanisms in many if not all the social Hymenoptera.

Environmental conditions that regulate the amount of nutriment extracted from the ripe ovarian egg by ovisorption also regulate the activities of the spermatheca, so that, as a rule, all the eggs that have been subjected to the ovisorptive process are fertilized, and most of those not so subjected are unfertilized.

The make-up of a typical colony (a relatively large number of workers, a small and more variable number of males, and one or several queens) is based on the reproductive responses of the queen to environmental conditions. However, in the honeybee, the low proportion of reproductives is an effect of the relatively few queen and male brood cells; in the ant, it may be an effect either of the deposition of a relatively low number of nutrient-complete eggs or of the destruction of a high proportion of such eggs by cannibalism, an exaggerated trophallactic reaction of the workers to the more highly nutrient egg.

The ovisorption process by its graduated effect on the eggs (prior to the point of injury) allows for the fullest expression of the polymorphic potentialities inherent in the germ plasm. This may result in the occurrence of caste intergrades in certain species of social Hymenoptera, whereas there are none in other species.

Ovisorption and its Effect on the Egg

Ovisorption or regression of the ovarian egg, according to Wigglesworth,[10] is probably the result of the interaction of nutrition, metabolism, and specific hormones. It characterizes hymenopterous species in which ovigenesis is more or less continuous throughout the life of the female, and in which ovulation is externally induced and immediately precedes oviposition. The processes of ovigenesis and ovisorption form a more or less continuous cycle.

In many Hymenoptera, ovisorption is the principal means of disposing of the ripe egg. This has been conclusively demonstrated in certain parasitic Hymenoptera in which oviposition is highly specialized.[6] Such species include those of the family Encyrtidae, whose eggs are equipped with an aeroscopic plate that is never completely absorbed and that remains in the ovariole as a readily recognizable remnant of the egg. The honeybee, likewise, may not deposit many of the eggs that she produces.

The extent to which the regression of the egg is completed varies with the species. In some, no visible remnant of the egg remains in the ovariole; in others, the entire content of the egg is extracted, but the eggshell remains intact and is never ovulated. With the honeybee and the ant the eggshell is completely absorbed.

During the process of regression in the honeybee the contents of the undeposited egg separate into a major portion consisting of a white, coarsely granular substance, and a minor portion consisting of a yellow, finely granular substance restricted to the posterior end of the egg. This yellow material remains in the ovariole as a small yellow disc, so that the yellow coloration of the ovaries increases with the number of eggs absorbed and, consequently, with the age of the female.

The ovisorptive process permits the deposition

of viable, partially regressed eggs. Such eggs may or may not be noticeably smaller than the unregressed eggs.

The complete regression of the ovarian egg is apparently accomplished in about the same length of time as is its genesis. In the chalcid *Metaphycus helvolus* (Comp.), the development of a primary oogonium into a ripe egg and the deposition of that egg require only 3 days at 80° F. At this temperature, the regression of the egg, assuming that this begins at the time that the egg becomes ripe, is completed in less than 2 days.[11]

Whiting[12] has found that the ripe ovarian egg may be retained in the ovary of the chalcid *Microbracon* for 36 hours without injury. Nonviable eggs in the process of regression, but with the chorion intact and with fluid content, can be ovulated and deposited. A female of *Metaphycus luteolus* (Timb.), after being withheld from her host for 3 weeks at about 80° F., deposited viable as well as nonviable eggs, the latter being partially collapsed; the completely collapsed eggs were retained in the ovary.[5]

If ovisorption begins as soon as the egg becomes ripe, the amount of material extracted from the egg will vary with the length of the preovulation period and the rate at which ovisorption occurs. The length of the preovulation period in species characterized by ovisorption is determined by the rate of oviposition, which, in turn, is determined by the environmental conditions that influence the oviposition responses of the female. Similarly, the rate of ovisorption is determined by the physiological state of the female, which, in turn, is determined by such environmental conditions as relative humidity, etc.

Differences in rates of ovisorption may be responsible for the fact that the ovaries of the gravid female of *M. helvolus* contain more ripe eggs when she is ovipositing continuously than when she has been prevented from ovipositing for a day or two. It is possible, however, that this difference is an effect of a reduction in the rate of ovigenesis, since the female of *M. helvolus*, when kept from her host, is deprived of nitrogenous food.

Whiting has shown that, with *Microbracon*, limited embryonic development occurs in about 10 per cent of the eggs deposited by out-crossed females, and in about 50 per cent of the eggs from close-crossed females.[13] The percentage of eggs that may have been injured by the absorption process was considerably greater, however, since the deposited egg "shells" that dried up quickly were not included in the hatchability ratios. Presumably, the inhibition of embryonic development is the effect of the lack of sufficient nourishment. Since the nutritional needs of the developing male are less than those of the female, a greater mortality of the female is to be expected. In this connection it should be noted that both Salt and Rempel[4] observed that an upset of nutritional balance may initiate reactions that produce sex reversal and intersexes.

The Ovisorptive Process as a Factor Affecting the Developing Individual

It has been demonstrated experimentally that in the Hymenoptera the undernourishment (inanition) of the developing individual is the primary cause of behavioral and morphological differences in the adult. In the honeybee, undernourishment is brought about by progressive-type feeding of the larvae;[4] in the gregariously developing wasp *Melittobia*, by a change in the nutritional qualities of the host;[14] and in the prepupal queen ant, by the parasitic extraction of assimilated food.[15]

Ovisorption appears to be the undernourishing mechanism in the bee *Melipona*. In this bee there is a distinct worker caste, although the brood cells are the same in size and are mass-provisioned with the same kind of food.[16] Kerr[17] found that differences in either the quantity or the quality of food ingested during the larval stages had no effect on differentiation of the castes. The worker population is constant, but the male population varies with the age of the colony. The virgin queens are killed by the workers if the mother queen is present. Kerr[18] suggested that the ratio of queen-producing eggs to worker-producing eggs is a possible effect of ovisorption.

In the army ant, *Eciton*, whose colonies multiply by division, the queen produces brood after brood consisting entirely of workers. Occasional broods consisting of a large number of males preceded by a few queens appear only during the dry season. Schneirla[3] states that a reasonable hypothesis to account for the occurrence of the sexual brood would be a reflex-physiological change in the gravid queen as a result of her first impact with dry-season conditions. It is probable that this change consists of a marked reduction, either in the rate of ovisorption—this being a possible effect of reduced oxygen supply resulting from the closing of the spiracles to prevent desiccation—or in the time between the ripening of the egg and its ovulation—this being an effect of an increased responsiveness to oviposition stimuli. The egg under such conditions would suffer little if any regression, and consequently would develop into either a queen or a male. The high population of males that follows

the appearance of the few queens in the occasional bisexual brood indicates a reduced responsiveness of the spermathecal gland to oviposition stimuli, so great that the hydrostatic pressure needed to accomplish fertilization[9] is not maintained after the deposition of the first few eggs.

This hypothesis of a reflex-physiological change in the gravid queen resulting from the abrupt exposure to dry conditions is equally applicable to aculeate colonies that are established by single queens. The queen has a high capacity for ovigenesis, but the number of eggs she lays and the rate of egg laying are dependent on the size of the worker population, the amount of food utilized, and the space occupied. In the seasonal growth of such a colony the general sequence of events is that the first brood consists of small workers and the succeeding broods of larger workers. After the largest workers have appeared, the queen and males are produced.

Falconer Smith informs me (*in litt.*) that he observed that mature colonies of *Camponotus* found in small, isolated logs may contain minors, medias, and majors, as well as winged males, whereas at the same time of year in much larger colonies of the same species living in larger logs all members of the worker caste may be represented but no males.

In the growth of a claustral-type colony most if not all the eggs deposited early are fertilized; consequently, it is probable that colony conditions that regulate the interval between the ripening of the egg and its ovulation also regulate the activity of the spermathecal gland, conditions causing a short preovulation period after ripening also causing a decrease in the responsiveness of the gland. If the eggs produced early are deposited more slowly than those produced later, the rate of deposition of the former would expose them to the process of absorption and at the same time ensure the fertilization of each.

This type of colony formation is well illustrated in the pollen-feeding bee *Halictus malachurus,* as observed by Stockhert.[19] During the spring the overwintering female lays eggs that develop into worker females morphologically distinct from the mother. As the season progresses the overwintering female deposits eggs that develop into short-lived males and overwintering females. The males mate only with the overwintering females. The old overwintering female lives until the end of the season, still with ripe eggs in the ovary and with an abundance of sperm in the spermatheca. The peculiar character of a sequence of events of this type is illustrated by the experiments of Goetsch[1] with the ant *Pheidole pallidula.* He showed that eggs of young queens transferred to old colonies still gave rise to nanitic workers. The determination of such workers he considered to be a matter of quantity of food available during their embryonic development.

It may be suggested that the extraction of nutriment from the deposited eggs by the workers caring for them may result in undernourishment and thus determine the caste. If such were the case, it is not likely that the castes in all species of social Hymenoptera would be limited to the female sex, since it is improbable that the worker can distinguish between fertilized and unfertilized eggs. It would appear, also, that the eggs of parasitic species should develop into workers, males, and queens in about the same proportion as with the eggs of the host species, the eggs of both species being exposed to the same environmental influence. Significantly, the only species of ants lacking workers are certain parasitic species. The parasitic species that occasionally produce workers are characterized by individuals that are intermediate, as to some characters, between the queen and the typical workers.[16]

Undernourishment of the embryo may or may not be indicated when a female deposits eggs that differ noticeably in size. The structure and the physiology of the hymenopterous ovariole evidently preclude the deposition of eggs before they attain the normal maximum in size. The assumption that a small egg is an effect of precocious deposition is unwarranted, since it is known that the ovarian egg can become smaller *after* it obtains its maximum size.

It is well known that in an ant colony the workers may deposit eggs that vary considerably in shape and volume. This variation is probably an effect of different workers producing eggs of different size. Weyer[20] observed worker eggs that were larger than those produced by the queen. According to Autuori,[21] the queen of the fungus-feeding ant *Atta sexdens,* during the early life of her colony and before any fungi are present, deposits two kinds of eggs, a small egg that develops into a worker and a large egg ten times the volume of the small egg. The presence of fungi and a correlated high humidity may result in a reduction in size, through absorption, affecting all the eggs produced by the queen. According to the ovisorption hypothesis the biparental queen-producing egg of a given species is always constant in size.

Differences in egg size may not result in corresponding differences in the size of the embryo. According to Rosenberg,[22] the eggs of the ichneu-

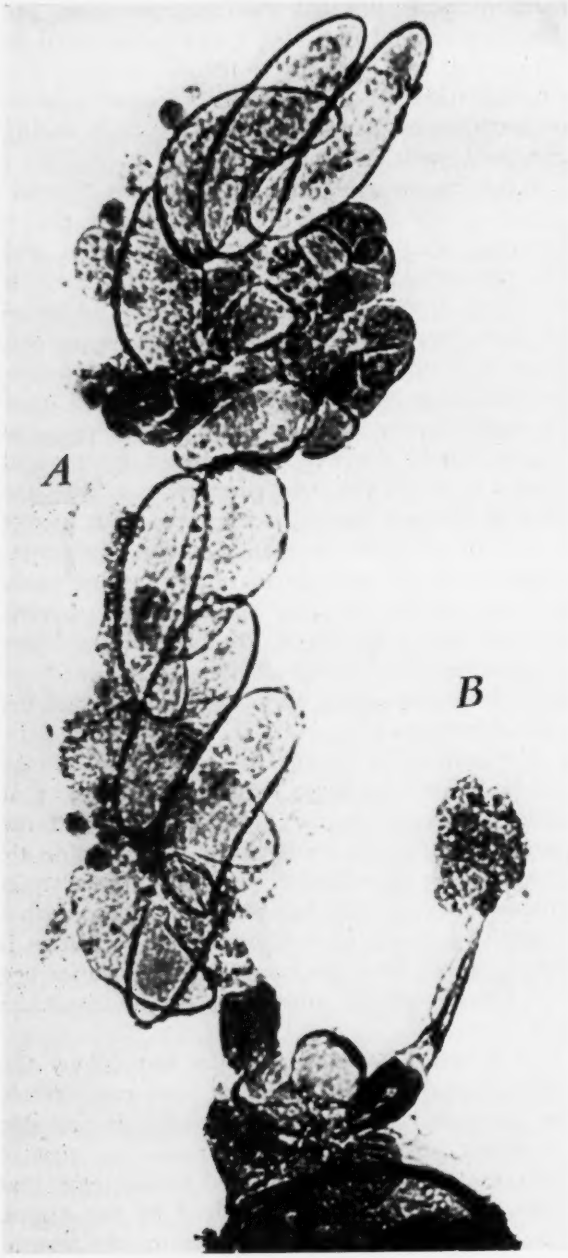

FIG. 1. Two ovaries of a *Dibrachoides* sp. female removed 6 months after she had become adult. During the first 5 months of this period both ovaries were in a condition of "phasic castration," as in the ovary at the right (*B*). During the sixth month, ovigenesis and ovisorption occurred in one of these ovaries (*A*), and 10 of the eggs were deposited. Nine of these eggs developed into females. Ovigenesis occurred in the first and last females becoming adult (the "queen" type); the others, after becoming adult (the "worker" type), were in a condition of "phasic castration."

mon *Ephialtes extensor* also differ in size, the length of those deposited late in the life of the female being about one half that of eggs deposited early in life. Rosenberg's data indicate that larvae, when newly emerged from the long and short eggs, are themselves quite uniform in size. Aside from the shrinkage of the eggshell, the occurrence of ovisorption is indicated by the fact that certain females commonly deposited nonviable "collapsed" eggs. Rosenberg points out that "eggs which are extremely short may hatch; but some evidence was obtained indicating a lower viability in these eggs."

Caste development in the wasps and bumblebees may represent a primitive stage in the evolutionary development of the stingless bees, the honeybee, and the ant. The difference between the workers and the queens of wasps is small, and intermediate forms are numerous. According to Wheeler,[19] quantitative feeding during development probably accounts for the production of these intermediate forms, but it should be noted that quantitative feeding, if undernourishment is not involved, will result only in a difference in size, not in structure or in behavior. Experiments by Falconer Smith,[23] with the incompletely polymorphic ant *Camponotus pennsylvanicus,* show that adult stature can be altered by conditions which exist between the time that the imaginal size is determined and the time of pupation. The basic imaginal size appeared to be determined at an early stage in the life history of this ant. The effect of larval overfeeding is illustrated in *Eciton,* the sexual brood exhibiting a marked increase in individual size over that of the worker brood.[3]

Eighteen years ago, while experimenting with the propagation of the alfalfa weevil parasites *Peridesmia, Spintherus,* and *Dibrachoides,* I noted two types of adult females, gravid and nongravid, that might well be representative of the prototypes of the female castes in the wasps. As in the wasp, the gravid and nongravid states were temporary. A female of *Dibrachoides,* for example, that had been in a nongravid condition for five months at room temperature became gravid in one ovary (Fig. 1) and deposited ten eggs during the following month. The diet of this female consisted of honey and the body fluids of the host. Nine females were reared from her eggs. Only the first and the last, upon becoming adult, were gravid; the others were nongravid or in a condition of diapause, or phasic castration.[24] There was no noticeable difference in the size of these adults, so that undernourishment during the larval stages was improbable. Simmonds[25, 26] has observed the occurrence of a larval diapause in the chalcid *Spalangia drosophilae* to be a maternal effect: the older the female at the time of oviposition, the greater the proportion of her progeny that entered a diapause.

He also noted that this proportion decreased at higher temperatures. It was evident that the incidence of diapause was influenced by "prenatal" factors acting on the ovarian egg. We may assume, therefore, that the condition of phasic castration, or diapause, which characterizes the adult workers in certain social wasps also is initiated in the egg. The worker, which closely resembles the queen, readily becomes gravid when egg laying by the queen is temporarily suppressed.[27]

The temporary cessation of ovigenesis in many Hymenoptera is correlated with the phenomenon of ovisorption. The black scale parasite *Metaphycus helvolus* is an excellent example of a species having the capacity to stop ovigenesis. The stimuli causing the cessation of egg production in *M. helvolus* are not purely psychological, as appears to be the case in *Peridesmia*;[24] this response is derived in part from the lack of protein food. In both species the cessation of ovigenesis and the complete regression of all ovarian eggs at room temperature is not immediate but requires a period of 3 weeks.

The periodic cessation of ovigenesis in the *Eciton* queen, according to Schneirla,[28] is an effect of periodic underfeeding, which occurs when the nutritional needs of her developing larval brood are high. Ovisorption in this ant is undoubtedly an essential and regular physiological process.

Ovipositional Factors Effecting Ovisorption

Since, in the social Hymenoptera, ovisorption is either limited or precluded by ovulation, and since ovulation and oviposition in such insects are almost simultaneous responses to the same environmental stimuli, it is necessary, for an understanding of the role of ovisorption in caste determination, to recognize the factors that determine the responsiveness of the female to oviposition stimuli—factors that may cause delayed oviposition. Such factors include lack of supplemental stimulation, a low quality of stimulation, a low relative humidity, aging of the female (as in *Ephialtes extensor, Microbracon hebetor,* and *Spalangia drosophilae*), low frequency of oviposition, preferential oviposition (as in *Pimpla examinator*), the amount of foraging and nursing activities (as in the wasps and ants), spatial requirements (as in *Peridesmia*), presence or absence of sperm in the spermatheca (as in *Melittobia*), and possibly differences in source of sperm, as from related or unrelated males (as may be the case in the honeybee).

The psychological effect on the female of the presence of sperm in the spermatheca is revealed in a number of parasitic species. In certain braconids that oviposit as readily before mating as after, as in *Macrocentrus ancylivorus* Roh., the presence of sperm in the spermatheca causes a psychological reaction that inhibits further mating. In this species, impregnation of the female is accomplished by means of a spermatophore. Mating is not inhibited until the spermatophore is connected with the spermathecal duct. In certain chalcids that oviposit as readily before mating as after, as in *Coccophagous cowperi* Gir., the female without sperm in the spermatheca deposits her eggs only externally on the larval body of a hymenopterous parasite inhabiting the mummy of a mealybug or scale insect; this same female when impregnated deposits her eggs only in the body fluids of a living scale insect.[29]

The influence of the condition of the spermatheca on the psychology of the female is well illustrated in the chalcid *Coccophagus ochraceus* Howard, parasitic on black scale. The progeny of the mated female, unlike that of *C. cowperi,* consists of both sexes. When the spermatheca contains sperms, the condition of the spermathecal gland determines whether the female stands on top of its host and oviposits in the blood or stands beside the scale and places an egg underneath it. When the rate of oviposition is high, the gland becomes nonfunctional (probably because it is temporarily depleted), and a male egg is placed under the host. When the gland again becomes functional, a female egg is placed in the body cavity of the same host.[29]

Since the condition of the spermatheca markedly affects the behavior of the hymenopterous female, it would not be surprising if her responsiveness to oviposition stimuli were determined by very slight differences in the spermatic fluids of different stocks of the same species. Experiments by Schmieder and Whiting[30] indicate that the fecundity of the female, when mated with a closely related male, is decreased in the case of the parasite *Microbracon* and increased in the case of the parasite *Melittobia,* in comparison with the fecundity of a female mated with an unrelated male.

When a female contains sperm from a male with which she would not normally mate, her responsiveness to oviposition stimuli may be lessened and the amount of ovisorption correspondingly increased. In this connection, observations by Mackensen[31] on the oviposition responses of queen bees that are artificially inseminated are significant. In the honeybee, as in other social Hymenoptera, the unmated, gravid female does not oviposit readily. The queen bee usually begins to oviposit from 3 to 4 days after mating. According to Mackensen, however, artificial insemination has very little if

any effect on initiating oviposition, the impregnated queens laying at the same age as virgin queens. This indicates that spermatic material, when so transferred, loses its capacity to stimulate oviposition. The probable nature of this loss is revealed by Mackensen's experiments showing that, when carbon dioxide gas is properly applied to artificially inseminated queens and to virgin queens as well, oviposition begins about 20 days earlier than is the case with untreated queens.

It is evident that the oviposition response of a hymenopterous female in which ovisorption is precluded only by oviposition is highly specialized and finely adjusted.

On the basis of the evidence presented herein, it is considered that polymorphism in the Hymenoptera is largely if not entirely limited to species in which ovulation is externally induced; that in such species ovisorption is precluded by oviposition; and that in some if not most social species caste determination is an effect of undernourishment of the embryo brought about by the extraction of nutriment from the ovarian eggs. The occurrence of such undernourishment would confirm Wheeler's[19] observation that in social insects starvation is exquisitely regulated and exploited.

Polymorphism in the Hymenoptera is not genetically limited to one sex, yet in the social species all castes are female, the male not being subjected to conditions that cause polymorphic differentiation—that is, the male is never undernourished during development.

In the social Hymenoptera whose nests lack structures for forcing the undernourishment of a portion of the larval brood, the determination or control of the worker caste appears to be a function of the environment acting through the queen.

The ovisorptive process appears to be an adequate mechanism for the determination of caste in social Hymenoptera, fulfilling all the requirements for such a purpose. It appears to be the only explanation for the deposition, by a single female, of eggs that differ either in volume or in content. It is the principal means by which species highly restricted in the deposition of their eggs can dispose of such eggs and become nongravid.

Partial ovisorption may result in undernourishment of the embryo, a condition that apparently determines its course of development, the end result being the occurrence of the worker caste, the gradations of caste as exhibited by the weakly differentiated castes of the wasps and bumblebees and the highly developed castes of the ants being genetically determined.

The factors that may regulate the amount of nutriment extracted from the ripe ovarian egg are environmental, the relative humidity affecting the rate of ovisorption, and the oviposition responses of the female regulating the amount of exposure of the egg to the ovisorption process.

The gravid and nongravid types of female in pteromalid parasites of the alfalfa weevil, and the poorly developed worker castes in the wasps and bumblebees, may be the equivalents of the evolutionary prototypes of the castes in the ant.

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Professional Education and the Disciplines:

An Open Letter to Professor Bestor*

WILLIAM CLARK TROW

very good

Dr. Trow (Ph.D., Columbia, 1924) is professor of educational psychology at the University of Michigan. A revised edition of his Educational Psychology *and one of the "Junior Citizen Series," of which he is coauthor, have recently been published. He is also coauthor of* Human Values in Elementary Education, *and editor of and contributor to* Educational Psychology in Teacher Education. *During the war he directed the University Civil Affairs Training School and later was a member of the first United States Education Mission to Japan. He is associate editor of the* Journal of Educational Psychology *and president of the Educational Psychology Division of the American Psychological Association.*

I HAVE just finished reading your article in the SCIENTIFIC MONTHLY attacking various aspects of the American educational system. It led me to wish you had read "Bury the Hatchet," by James B. Conant, in the National Education Association *Journal* for May 1951. I hope you will read it, for it is in the spirit of that article that this reply is written. The point Dr. Conant makes is that continued feuding between professors of education and professors of the traditional academic subjects is not an effective method of improving our schools.

A better procedure might be to try to find some areas of agreement and, as we move out from these, check on our facts and note some of their implications. It may then be possible to work out plans that would have some influence of a beneficial sort.

Areas of Agreement

The first of such areas of possible agreement would, I think, be our common concern for public education, our recognition that it is far from perfect, and that improvements can and should be made. This is fundamental, for there are those in our country who are attacking the public school as an institution and seeking to destroy it. This hostile view is as old as tax-supported education itself, but I assume that it is not held by you or by most of the critics of the schools in our colleges and universities. If this point is not clarified, American scholars are likely to find themselves unwittingly included with the ignorant and the malicious.

We can agree, too, I believe, that there are many teachers in our schools who are not qualified to teach. I would suggest that the numbers of teachers required, the conditions of their work, the salaries paid, and the attractiveness of other kinds of employment are probably more important reasons for the unfortunate situation than the one you emphasize—i.e., the multiplicity of education courses they are required to take.

Closely connected with this is your statement with which I, for one, would agree, that the professors in academic fields are at least partly to blame for some of the weaknesses of our public school program (catastrophe seems a little too strong a word). I believe their failure is not so much that they have allowed various things to go on, as that they have tended to lose contact with the schools. One consequence of this is that academic course offerings (not all by any means) are unrealistic, in that the teachers do not see how the courses they are required to take will help them to do the things they have to do.

And I am sure you would agree that some education professors are not as competent as one could wish. This is true, of course, of other professors, and of the members of other professions. It is difficult to judge the competence of men in other fields, and we might be willing to agree to leave the mat-

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ter to their colleagues, or at least confine our indictments to individual cases where the facts are available, and avoid too broad generalization.

Finally, I wonder if we can agree to dispense with name-calling. I regret as much as you the language used by Willard B. Spalding, although in your footnote which quoted him you said nothing of his provocation. And your reference to "medicine men" does nothing to strengthen your case. Let's have our say without sticking out our tongues at each other.

Consider the Facts

Now let us consider some facts. The trouble with such a complex subject as public education is that there are so many facts that must enter into any judgment on specific issues. But three or four will suffice for the present purpose.

There is actually no single body of knowledge and there are no disciplines that "throughout history . . . have been rightly considered fundamental to education." This is a fact, and since it is contrary to what is perhaps your basic contention, it is an important one to consider. Early education in China emphasized memorizing the Chinese literary classics, and the present rulers of China require "brain-washing" and Marxian dogma. The ancient Persians taught their young men to ride, to shoot, and to speak the truth, whereas modern Persians emphasize, among other things, memorizing the Koran in Arabic. The classical Greek curriculum consisted primarily of music and physical education. During the Middle Ages the trivium and quadrivium constituted the *pièce de résistance*, a program which few would advocate for American schools today. And so it goes. Each generation in each culture is called upon to select from the past and present what seems best and most important for the future, and naturally enough there is much honest disagreement as to what is best and most important. Even Jefferson, whose ideas were most enlightened for his day, advocated a selectivity that is quite different from the kind to which we subscribe, when in his Virginia plan he wrote: "By this means twenty of the best geniuses will be raked from the rubbish annually. . . ." Different cultures have developed different curricula, and modifications are constantly being made.

The second fact is that "genuine education" is not necessarily "intellectual training." There is ambiguity in the subject, and there is further ambiguity in the word "training," which to many is the antithesis of education. And even if one accepted your proposition that genuine education is intellectual training, there would be legitimate differences of opinion as to the process. To educators, it means the automatic transfer of training which Reeder picturesquely caricatured in the quotation you cited. True, "the traditional curriculum offered a clear-cut answer," but what evidence have we that it was the correct answer under all circumstances, even though its commendable aim was "to cultivate sound judgment based upon critical thinking and thorough knowledge"?

The third fact comes as a partial explanation for the incompleteness of the intellectual training idea, and it is this. The human brain is not separate from the rest of the organism. Teachers, and even college professors, have been a long time in realizing the significance of this truism. In spite of the academic concern for intellectual training, children persisted in bringing their bodies to school, and with them their interests and attitudes, their likes and dislikes, their ambitions, and their frustrations. Granted that the intellectual values are the ones the schools should emphasize, they are not developed in vacuo. There is something in the phrase "the whole man" suggesting that the implications would perhaps be better realized if critics of the educational program would actually spend some time in the schools and get acquainted with Joe and Oskar and Minnie and Julie. The educators feel no disrespect toward the disciplines as such; rather, they are concerned about what the pupils really learn and how they learn. Familiarity with the inside of a school building would make it impossible for anyone to state quite so glibly that "the intellectual power that mankind has accumulated throughout its entire history can be passed on to successive generations." It can and it can't. It is not on a tray to be passed along. It must somehow be re-experienced in the neuromuscular systems of flesh-and-blood youngsters.

And this leads to the fact of human variation: the children and young people in school differ widely in ability. Only about a quarter of the young people in high school go to college or are capable of profiting from the traditional college curriculum. The interest of those who speak for the intellectual disciplines seems to be with this group, and they could undoubtedly be of help in working out schemes to see that capable young people go to college, and in developing adequate programs for them, just so long as they do not insist that *all* young people in school follow these programs, and so long as the departments do not act merely as antagonistic pressure groups each for its own discipline!

Carrying the variation fact a step farther, we know by definition that half the people in the world are below average in intelligence. How shall children in the lower range be educated? And even if we grant that the disciplines are important at the college and graduate level, do they provide the best form of education at the elementary and high school levels? As for the pupils in the lower 50 per cent, most of them are capable of doing little more than memorize some of the terms and definitions. Theirs is a concrete world in which the disciplines are not separated, as in college departments. And it is conceivably the responsibility of the school to introduce them to this concrete world of gas stations and farms, of consumer buying and of housing, yes, of public health and sanitation. This is not "anti-intellectualism," and the schools are not being "wrecked" by it. (Though I would not be one to condemn a little hyperbole on occasion!) Instead, it is a serious attempt to help young people meet the kinds of problems they are likely to meet, just as work in the "disciplines" is a similar serious attempt to help other young people meet the kinds of problems that are likely to confront them.

Interpreting Results

So much for some of the facts and their implications. Now as to your critical comments based on your homework. I would certainly show myself to be hopelessly prejudiced if I came to the support of the questionnaire, at least as you described it. But before stringing up the Superintendent of Public Instruction by his thumbs, I should want to be sure that in the interpretation of the results the items were given equal weight, as you imply. It sounds to me as if the basic subjects were bunched together as commonly accepted material, but that information was sought about some of the more irregular items which somebody had been pressing for. In any case, isn't it a rather dubious procedure to select two studies (certainly the 1936 Michigan study you reported had very little influence) and imply that they are typical? The matter of sampling bothered Fuller, too. The selection of data to fit one's thesis, with the neglect or suppression of contrary data, is a practice I am sure neither of you would follow in your own disciplines. Why do it when you step out of your field? If your contention is that some educational writings are pretty poor, I will regretfully have to agree with you; but, frankly, the generalization from one or two samples not only throws suspicion on your argument, but also on the value of the intellectual training you advocate, which aims "to cultivate sound judgment based upon critical thinking and thorough knowledge." The practice may be one of the reasons that the educational process has moved along without as much benefit from the academicians as we might wish.

Finally—and here I run still closer to the danger of seeming to continue "feuding' "—I come to another point which makes us suspicious of specialists operating outside their field of specialization. I am sure that as a historian you would be very careful when you assign a cause to any event. In partisan oratory, it is of course the opposite party that is responsible. But the historical method decrees greater caution. Yet in the field of public education you do not hesitate to write: "There is no mystery about the source . . ." and then launch into a series of statements that give the case away with a fantastic and almost paranoid array of accusations, and with the facts selected and warped to fit the delusional system.

Let's calm down and look at the situation rationally. Why should all these educational bureaucrats gang up on the college professors? The "source" doesn't lie in any conspiracy. It lies in the culture. The superintendents, principals, and teachers are in contact with the people in the cities, towns, and villages of our country. And they are the ones who determine through school boards and legislatures what kind of education their children shall have. The professors of education are the ones who have studied the situation day in and day out, who have thumbed through the studies, hundreds of them, good and bad, and whose responsibility it is to *help,* not to stand aloof and criticize (pardon me, but that's the way it looks). And the "federal officials and bureaucrats," who have no legal power, call meetings and conferences, get out publications (of unequal value to be sure, but so are other publications), and put in long hours trying to help the teachers with their task of directing the development of the millions of children crowding our schools.

From this point of view, which is at least a reasonable one, the statements made in your last two pages frankly seem off the beam. Just read them over with such questions in mind as the following: Is this really so? Does prejudice enter in here? Do these facts really prove my contentions? Take one example—the departments of Education and Chemistry in the University of Illinois compared on the basis of size and estimated competence. The number of staff members is usually largely determined by the number of students. How many students, graduate and undergraduate, are enrolled

in the two departments? Or this: "Teachers are all but compelled to take that work not in the subjects they are teaching but in endless courses in education." Passing over the "endless" (which suggests prejudice)—of the teachers I have advised, some prefer to take an M.S. degree in the academic subject, but in that case they must take all their work in that subject. Many prefer a degree in education, which *requires* that one third be taken outside education, and *permits* one half.

Cooperation and Consecration Needed

Can you and your academic colleagues really help to improve the education of our young people? I think you can. And I suggest a few possible ways:

1. Appraise and modify your course offerings to be sure that the dead material is removed and the newer findings are included, that beginning courses in a department are not based on the false assumption that all who take them will concentrate in that department, and that some courses, at least, include content that teachers can use in their work.
2. Appraise and review methods of instruction, in part on the basis of student evaluation, and avoid the assumption that young people are being educated by being failed for their inability to regurgitate a term's work on a single examination at the end of a course.
3. Attend and speak at state and national meetings of teachers and school administrators, where your views can be freely discussed.
4. Arrange for lectures, symposia, and even workshops cosponsored by your department and the college or school or department of education.
5. Set up combined-degree graduate programs which provide opportunities for students to take work both in education and in an academic department.

All these plans are in operation in various institutions. You can perhaps think of other ways that include a cooperative effort to work out solutions for present-day educational problems, most of which will be found to be much more complex than they seem from a distance.

Such cooperation takes time, in conferences and in committee meetings, and, yes, it takes consecration. If you are really as serious as your article suggests, you may be willing to work toward some of the needed improvements. But if you come into a group or a committee meeting with all the answers dreamed up to hand out as if to unworthy menials who have banded together against you, you might as well stay home and read a good book. Those who have the responsibility for carrying on the work of the schools just will not be interested. People are like that. I can't help it. They just are.

If you and your academic colleagues are not willing to help in such ways as I have suggested, it should be realized that uninformed criticism is at best unbecoming and at its worst positively detrimental to the cause of good education. I believe that most education people would be glad to meet you more than halfway in any serious attempt to improve our educational program.

SEA-STUFF

I live in an electric sea
That flashes in and over me.
Electric is the solid ground—
Its particles like bubbles bound;
Electric the transparent air—
Rivers of fire flow everywhere,
Too vast, too luminous for sight.
Heaven and earth are only light,
The momentary shape of motion,
A dazzling, dancing, living ocean.
Heaven and earth are not enough—
I am myself this strange sea-stuff.

JAMES DILLET FREEMAN

Lee's Summit, Missouri

The Tutelo Harvest Rites: A Musical and Choreographic Analysis

GERTRUDE P. KURATH

The author is a pioneer in methods of ethnic choreography and musicology. An M.A. in the history of art and archaeology at Bryn Mawr (1928) intervened between periods of study in the dance, instrumental and theoretical music, and theatre techniques. Overlapping careers as a concert performer, teacher, and stage producer preceded her research in folk drama and American Indian ritual. Her field trips have extended from Mexican Otomí and Yaqui to the Woodland Sauk and Fox, Cherokee, and repeatedly to the Iroquois. Currently she is assisting in the development of a record collection and transcription service at the University of Michigan Depository of Regional Music.

DURING the past fifty years ethnographers have often displayed an awareness of music and the dance as cultural components, especially as factors in religious activity. Occasionally they have consulted a specialist, but as a rule they have contented themselves with a brief comment. A superficial commentary on these artistic components can be of little use to science; a thoroughgoing analysis may provide a valuable contribution. Scientific methods and research personnel have been lagging, however, notably in choreography, despite the potentialities of the material.

The paradigm chosen for exposition here is the Four Nights Dance, the Tutelo harvest rite, termed *geiniwašondáge* in the Onondaga tongue.* The Tutelo were a Siouan tribe, removed from the southeastern Piedmont to Ontario and now amalgamated with the Cayuga and Onondaga of Six Nations Reserve, Ontario. Their rituals survive in the Iroquois celebrations at the longhouses. The harvest rite challenges analysis because of its formal variety and its unsolved problems. The interdependence of music and choreography demand joint treatment, and their historical background demands consultation of all clues to the culture of the Tutelo. This process of analysis and synthesis, though prolonged, may be reduced to a summary of essentials.

The process of "laboratory" analysis is subject to control, but it could not exist without the observations and recordings that combine training with a good measure of old-fashioned luck. As it happened, I attended the Onondaga Green Corn festival on August 16, 1949, and was able to witness the Four Nights Dance because the necessary singers and dance leaders were present and the crowd was in a suitable mood. I was able to participate because it is a women's dance. Three years later the song recordings materialized because of the good will of the Michigan Academy of Science and of seventy-two-year-old Peter Buck, a Tutelo-Cayuga, and also because the dry weather permitted hitching the tape recorder to the car battery. During September and October, 1952, the choreographic notes were checked three times with Anne Greene, an amiable Cayuga-Onondaga matron and one of the leading dancers. She and Richard Buck, Peter's cousin, separately served as interpreters of the text paraphrase provided by Susan Buck Claus. This aged invalid, the only living person with any memory of the Tutelo language, spent many patient hours on the partial recognition of the song meanings.

During the examination of the collected materials, the transcription of songs, the study of the dance movements, we must bear in mind the first impression of mixed Iroquoian and exotic qualities. We ask, "What can the forms reveal about the tribal identity and the original culture?"

* Acknowledgment is due to the Michigan Academy of Science, hence the American Association for the Advancement of Science, for support of the field work; to William N. Fenton and Leslie A. White for their recommendation; to Joffre L. Coe for helpful comments on the manuscript; and to John W. Gillespie for the loan of a battery converter and of his field notes on Eastern Cherokee dances and on the Shawnee Bread Dance.

The Ritual

Four Nights Dance expresses thanks for a good crop of corn and other foods. As such it ordinarily forms the last part of Onondaga and Cayuga harvest ceremonies late in the fall, just before the concluding feast. It has shrunk from four nights' to an hour's duration. In the center of the spacious longhouse floor two benches are set up, and six male singers and several small boys take their places face to face. The song leader manipulates a small Iroquois water drum; the assistants shake horn rattles of recent Iroquoian make. Each song, which is started by the leader, is performed twice. At specific times women sing the repeat, and women are the dancers. Three costumed leaders start circling counterclockwise and, as usual among the Iroquois, in the course of time, other women and girls line up single file. On the observed occasion, the numbers swelled to thirty participants. Between songs the dancers saunter, but very briefly, for one song follows another immediately—no mean feat.

Even without pauses the ritual stylistically divides into eight parts. Its recording includes 40 songs, but it is not complete, for several songs were omitted in the second and last parts because of domestic incidents in Peter Buck's home. Otherwise this material is reliable and permits of safe deductions. The geometry of the dance steps is, on the other hand, approximate, because of individual variation and because of the taboo on photography.

One song from each section has been selected for reproduction. In every case the percussion accompaniment is written below the melody and the choreographic script above; in two instances the ground plan is incorporated. In the script the symbols are confined to the feet and knees so as not to confuse the reader. These symbols have been described in several publications—for example, in an article on the Iroquois Death Feast.[1] The method of scale weighting according to note frequency has also been explained before.[2] Some brand-new devices are introduced, however.

I. *Introductory Songs* by men, 1–6 (Fig. 1).
   1. Invocation to percussion tremolo.
   2–6. Songs to alternately accented duple beat.
   Character: short, syncopated themes in descending sequence—that is, repetition varied by level or contour.

II. *Tutelo Step* by men and women, 7–17 (Fig. 2).
   Music: 11 songs (should be 12), similar in character to Part I.
   Dance: Women's dance step—right foot diagonally right forward, left heel brushes ground next to right instep; reverse.

Fig. 1. The fourth introductory song is performed by the seated male singers and is not associated with any dancing.

   Torso nearly erect, turns slightly toward heel during brush.
   Single file, forward progression.

III. *Corn Mime* by men and women, 18–21 (Fig. 3).
   Music: 4 songs with same melody but varying words, to even slow beat.
   Character: Long sustained, balanced phrase repeated thrice in sequence.
   Dance: Tutelo step and progression as in Part II.
   Gesture different for each song.
   18. Husking corn: left hand in front of waist, closed, palm toward body; right hand moves obliquely down 12 inches during step and up during brush, to join left hand.
   19. Pounding corn: clasped hands close together in front of waist, move vertically down during step and up during brush.

Fig. 2. Songs 10 and 11 are typical of the second part of the ritual, where men and women sing and women dance.

FIG. 3. The third part of the ritual consists of four songs, 18–21, all with the same melody, and repeated by the women after the men's first rendering. At the same time, the women mime actions of the corn harvest.

20. Winnowing corn: clasped hands close together in front of waist, twist alternately right and left in rhythm.
21. Making cornbread: left hand held with flat palm upward, right palm rubs left in flat clockwise circles.

During small, precise gestures the body lilts gently, with rocking foot motion.

IV. *Side Shuffle,* with songs by men only, 22–25 (Fig. 4).

Music: 4 archaic songs, to tremolo and accented duple beat.

Character: somewhat irregular, medium length phrases in dwindling, level sequence.

Dance: Women face toward singers in center, slide right foot right, then slide left foot to join right.

Torso absolutely erect, no gesture, arms hanging relaxed.

Single file progression to right, with central focus.

V. *Enskänye Shuffle,* songs by men, 25–29 (Fig. 5).

Music: 4 songs with same melody but varying words, to tremolo and duple beat, in slower tempo during song 29 C.

FIG. 4. Song 22 introduces a contrasting section for male singers and women circling with a side shuffle.

FIG. 5. Song 29 concludes the fifth part of the ritual. To male singing the women amble, then dance the so-called enskänye step, then run backwards.

Character: repetitious theme betwixt prelude and coda.

Dance: Enskänye, or women's shuffle dance step, facing center, twist both heels to right, sliding right foot back a few inches; then twist both toes to right, sliding right foot forward a few inches.

Torso erect, no gesture; knees rebound during each twist.

Progression as in Part IV.

Composition of song 29:

A—saunter straight ahead during tremolo.

B—sideward enskänye step during duple fast beat.

C—run backward with tiny steps during slower beat, each woman holding on to waist of dancer in front.

VI. *Strawberry Search,* men and women, 30–31 (Fig. 6).

Music: 1 transitional song and 1 long song, to percussion tremolo.

Character: very long, sustained phrase repeated four times in descending sequence.

Dance: Stride resembling Tutelo step—but three times as long—for duration of a half note, left foot step obliquely forward and left; for duration of quarter note, lightly place right foot next to left; repeat same to right.

During left stride torso and knee flexed oblique left, during right step straighten somewhat and face forward.

During left stride left hand swings out to left as though brushing away leaves from plants, during right stride draw back toward body.

Though focus toward center, progression straight ahead.

FIG. 6. Song 31 constitutes the sixth part, an enactment of a strawberry search to male and female singing.

VII. *Tutelo Step,* men and women, 32–36 (Fig. 7).
 Music: 4 complex songs to accented duple beat which lags behind (syncopates) melody after first few measures; 1 transitional song, terminal female whoop.
 Character: pattern of two short themes in sequence and alternation.
 Dance: Same as in Part III.

VIII. *Pairing and Crossover,* male singers, 37–40 (Fig. 8).
 Music: 4 songs similar to Part IV, to tremolo and duple beat.
 Character: repetitious, short staccato themes repeated in horizontal sequence, lively and vigorous.
 Dance: Forward walk and enskänye step in following pattern:
  A—every second woman face about, so as to form pairs face to face.
  B—in time with even duple beat, all do enskänye step, in quicker tempo.
  A—to accented beat, partners change places.
  B—to even beat, all enskänye.
 During next song change back to original position.
 Brief forward saunter between songs and during first few notes; otherwise circle static in location, with animation in footwork and interchange.
 This climaxes the cycle and ends with a whoop by men and women, "Yuhup!"

Preferably text and translation should be incorporated into the song, but in this case they

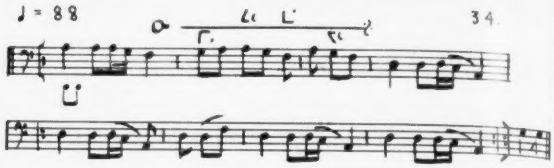

FIG. 7. Song 34 represents the seventh part, which resembles Part II in musical style and in the "Tutelo step" of the women.

would crowd the illustrations and are hence here quoted separately.

Fig. 1. *jiwagiho jiwagiho jiwagihonę | yonędi jiwagiho yoho.*
 'hoeing at their gardens [they are] yoho'
Fig. 2. *yowiyo henę yowiyo henę yowiyahe. he'e ho'o yowiyahe. yoho*
 'plenty corn [they are praying for a plentiful crop]'
Fig. 3. *| : wiyonka hinęndo: | yoho.*
 'fine corn seed [kernel]'
Fig. 4. *| : biwa do: | yoho.*
 'nice seed' [?], or 'thanks!'
Fig. 5. *hayondo jihane. hohoyondo wohe'e. wayo yondo wohe'e.*
 '[corn] soup' ?
 | :hohenoge: | yoho
 'go backwards'
Fig. 6. *yoho hewiyo hoyahane. yoho.*
 '[have] plenty fruit'
Fig. 7. *weyowane hawegi heyowane. yoho.*
 ?
Fig. 8. *hewagile hewagile hewagileda. yoho.*
 'I [we] must go home'

The text obviously refers to the corn crop and the connected dance action, in spite of the non-Tutelo-speaking singer's modifications, Mrs. Claus'

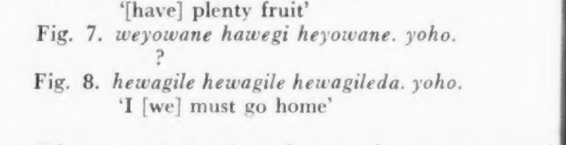

FIG. 8. The last part differs from the rest of the ritual. Like the other four songs, 34 is rapid. The dancers pair up and perform the enskänye step, then change places. Only the men sing. All end with a whoop.

frequent uncertainties and interpolations, and the diffusion through the Cayuga language. Some of the terms are new to us, others conform to scant vocabularies in previous publications.[3] As we cannot tarry on the linguistics, we refer to Horatio Hale,[4] Edward Sapir,[5] and Leo J. Frachtenberg.[6]

Analytic Devices

Stylistic variety may already have become apparent in the course of the descriptions and illustrations. This contrasts with the unusual homogeneity of the previously analyzed Tutelo Spirit Release Rite.[7] Eclecticism, therefore, is not a Tutelo characteristic and must have another reason. The precise nature of these styles can be ascertained by analysis of the musical tonality, structure, and rhythms, and of approximate choreographic measurements. The differences may imply the reason.

Tonality. Weighted scales give the clearest picture of the tonal material. They can be reduced to three types, a quartal scale based on a nucleus of fourths; a quartertial one, combining fourths and thirds; and a tertial one based on thirds, without excluding other intervals (Fig. 9). In most cases the tonal nucleus (marked by a bracket) hovers at the bottom of the scale, by the lowest or main tone (marked by a whole note with hold). Song 18 (Part III) has two nuclei focused on the center of the scale. The arrangement on the figure shows two progressions in the course of the rite from the quartal to tertial song groups. It does not show that Part I contains two quartertial songs and Part VII two quartal songs. The first scale varies in compass from an octave to a fifth, the second scale always contains a seventh or octave, and the third one is confined to a fifth. The performance of the melodies with their scales may also be analyzed.

Structure. Five of the song samples work with a single motif, *a*, and vary it by repetition on a lower level by changing the intervals. In Part III the motif has two phrases in balanced pattern. Part VII uses two themes, and Part V two themes and a coda. The manipulation formula can be symbolized by numerical designation of the highest and lowest tone in each phrase. Thus, 8:5:8 means "start on octave, dip to fifth, end on octave." The numbers in the following examples refer to the *tones* of the scale; *a* and *b* refer to themes, of which there is usually only a single one (namely, *a*), and perhaps a variant, *a′*.

Fig. 1—a 8:5:8 a 8:4 a 5:1
a′ 8:5:8 a 8:4 a 5:1
a 1:1 1:1 a 4:2:4 5:1

Fig. 4—a 3:5 a 3:1 3:1 a 1:2:1 1:2:1
Fig. 5—a 4:5:1 b 4:1 b 2:1 2:1 c 1:1 1:1
Fig. 6—a 8:6 a 7:8:3 a 4:6:1 a 1:4:1

This device shows the compass of each phrase, as well as its place in the scale. It shows how successive phrases descend the ladder, how two of the samples also begin on the highest tone, and all end on the lowest. An ensuing device will tell still more about the behavior of the phrases, their pattern of level, and compass. The symbol 8:5:8 indicates an interval of a fourth, for instance. Such symbols will now be shown in their respective levels for all eight songs. In the left-hand column we show the compass of the entire song. The numerals, *4*, etc., now represent *intervals*. The grouping will follow the scale type in Figure 9.

SONG COMPASS	PHRASE COMPASS
I. *8*	*: 4*
	5
	5 : 3
	1 1 5
II. *5*	*4*
	4 4 4
	1 1
III. *7*	*4*
	7 6
IV. *5*	*3*
	3 2
V. *5*	*5 4 2 1*
VI. *8*	*3*
	6
	6 4
VII. *8*	*3 3*
	3
	4| : 4 4 4 :|
VIII. *5*	*3*
	3
	3 3 3

Patterns

descent, shrinkage to monotone, 4th common	descent, central expansion, final shrinkage, no monotone, 6th and 7th largest	descent, shrinkage not to monotone, 3rd common

Each scale type exhibits special characteristics. Notably, the quartertial scale shows the broadest expansion, and the tertial scale the least contrast between phrases. Naturally the songs with limited compass are more level than those that encompass an octave. But every single one descends obliquely and sequentially.

After this abstraction and grouping one should return to the actual melodies for an appreciation of the ingenuity of thematic development, simpler in the case of the tertial songs, still regular in the quartal tunes, and more flexible though not extremely intricate in the hybrid scale type. At the

FIG. 9. "Weighted scales" show the tonal material of the eight parts of the ritual. They fall into three types, with varying structure and compass. The brackets show the tonal nucleus of the songs in Figures 1–8.

same time one can perceive the structural coherence and orderliness of each song and of the whole cycle.

Now for one more process of dissection—that is, the extraction of the smallest typical rhythmic unit in each melody and their grouping by the scale types, with the percussion beat included under each rhythm.

Rhythms. As in the case of thematic development, the rhythmic pattern varies with each song. However, the units in Figure 10, based on the song examples, can be considered typical. Although they speak for themselves, their relationship to scale grouping deserves a brief comment. The first and third scales contain lively, crisp rhythms, including syncopation in the first group and broken units in the third. The second scale contains placid, symmetrical units. The quick notes in 7. relate to the unit of 2. Parts VII and II are connected by the same dance step, we may recall. The liveliest rhythms are enhanced furthermore by the fastest tempi, especially toward the end of the cycle.

The duple drum beat predominates. After the first 17 songs a tremolo introduces each new melody. In 3. this is followed by a smooth slow beat; in 7. it perseveres as a sustained, wavering undercurrent. These are the mimetic songs, with long, sustained phrases.

On the whole, the rhythmic complexity is in inverse proportion to scale size and structural complexity. The most limited melodies make up for their repetitiousness by rhythmic interest within the phrase, and by more emphatic rendering.

Choreography. The ground plan consists in a steady counterclockwise circling until the final crossovers, but the step changes frequently. So we shall confine the analysis to the fundamental steps already described: the "Tutelo" step-brush and its stride variant, the side shuffle, the sidewards enskänye, and the interpolated walk, saunter, and backward run. The stride length in inches and the angle of flexion will be tabulated in the simplest terms, and the step types will be related to the scale types (Table 1).

Steps and Scales

Quartal	Quartertial	Tertial
I.		
II. Tutelo step		
	III. Tutelo step Mime	
		IV. Side shuffle
V. Enskänye		
	VI. Tutelo stride Mime	
	VII. Tutelo step	
		VIII. Enskänye

The feminine style is usually characterized by tiny, prim motions, as in the side shuffle, enskänye, and back run. Usually the knee flexes slightly with each impulse, although the posture remains erect. The Tutelo step is slightly larger, with mild torso inclination. The stride contrasts with the typical style by its length and the forward bend of the body. The Tutelo step and mime are associated with the second scale, the step alone also with the first scale. Enskänye is danced to songs of the first and third scales; the side shuffle is confined to the archaic group of tertial songs. Thus, as it happens, the tiniest steps accompany the most limited melodies; the largest movements, including the gestures, accompany the more elaborate, expanding themes.† Obviously these larger movements also require a slower tempo than the crisp shuffles like the enskänye.

Pattern of the Entire Cycle. Both musically and choreographically the rite falls into two large parts. The alternation of scales divides it into two halves I–IV and V–VIII. The tempo and step type divide it into I–V and VI–VIII. The fast enskänye in V brings a minor climax, then a reversal of direction in the backward run and return to the slow tempo.

† This would agree with Curt Sachs' observations on *Engbewegung* and *Weitbewegung* (confined and expansive motion), in *Eine Weltgeschichte des Tanzes.* Berlin: D. Reimer, 127–32 (1933).

TABLE 1

(See Fig. 11)

Step	Measurements						
	Length of Step (inches)			Angle of Flexion°			
	Forward	Side	Back	A Knee	B Torso	C	D
Tutelo stride	18	12		100	40	90	50
Tutelo step	6	6		140	20	140	20
Side shuffle		4		140	20	160	0
Enskänye		5		140	20	170	10
Back run			4	130	25	130	25

The last part works up to the real climax. Each half contains a mimetic section.

The center and end are emphasized in another way. Parts IV and VIII are melodically the most archaic, Part IV, also choreographically. The pattern of relative complexity could be expressed in an inverted pyramid, with the archaic Part IV at the bottom and, musically, also Part VIII.

I VII VIII (dance)

III VI

II V

IV VIII (music)

Before turning to the interpretation of these numerical and stylistic patterns, we must call attention to the prevalence of the number 4 and, secondarily, of 6 and 12 in the song groupings. Although this division is not as rigid as in the Spirit Release Ceremony, it is nonetheless evident and significant.

On the Tutelo Trail

The stage is now set for an attack on the problem of identification. Do the analyzed qualities brand the rite as (1) Iroquoian, (2) Tutelo, or (3) something else?

1. The first assumption would not be unreasonable in view of two centuries of proximity, of recent transference to Six Nations longhouses, and of the "Iroquois feel" of many of the songs and steps. This can be answered quite precisely because of the thousands of Iroquois songs available in recordings studied by the writer. The huge repertoire contains a great variety of scales and structural patterns, along with a rich dance heritage. A thorough search tells the following story.

Music: The first and third scales are prominent in Iroquois music, the 54 21 scale especially in the women's Death Feast and other medicine rites and in some animal rites, the 5 3 1 scale in several esoteric rites, in a more developed form also in maize songs and the "Fish type."[7] But the second, 43 1 scale, occurs only in one instance, the Death Feast, songs 64–67.[8] This rite bears several resemblances to Four Nights Dance. The structural forms of descending sequence and dwindling repetition, the rhythms, the terminal call, the echoing of the songs by a female chorus, all could conceivably be Iroquois. Thus only one element, uniqueness of scale, isolates two parts of the rite, III and VI. This element is the most stable and fundamental of all and thus most significant.

Dance: The counterclockwise circle comprises nine tenths of Iroquois dance forms. The paired crossover concludes a number of rites and constitutes the pattern of the "Fish type."[9] The side shuffle predominates in medicine rites, as in the Death Feast. The enskänye step threads through all of Iroquois ceremonialism, including the "Fish

FIG. 10. The rhythmic figures are grouped according to the scale types of the eight parts of the ritual. On the staff is written the fundamental melodic unit of the songs in Figures 1–8; underneath is the rhythm of the percussion instruments.

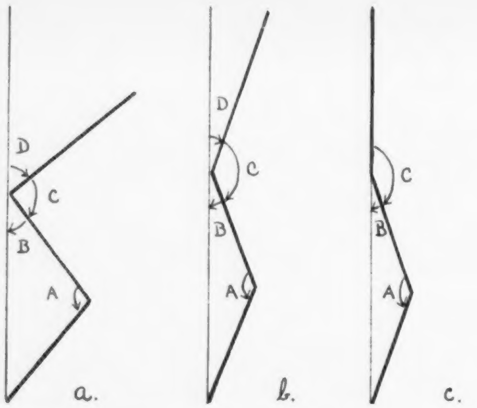

FIG. 11. Rudimentary silhouette of knee and torso angles in forward flexion: (*a*) Tutelo stride, (*b*) Tutelo step, (*c*) side shuffle. Enskänye step is slightly more erect and back run is little more flexed than (*b*). These represent only two of the many measurements involved in accurate choreographic analysis.

type," maize dances, and the end of Death Feast;[10] however, the "Tutelo step" is atypical. In only one Six Nations Dance is it duplicated, in a variant form—in the Delaware Skin Dance taken over from that tribe. The associated mime finds no equivalent. Enskänye dancers may, if they wish, use tiny, angular, stylized gestures,[11] but never in unison, never as an occupational imitation, and *never* with large strides or sweeping arms. The step in Parts II, III, and VII exceeds the enskänye dimensions only slightly, the stride in VI contrasts completely and surprises the spectator accustomed to Six Nations stylistic restrictions.

In sum total, Parts III, VI, and VII depart musically and choreographically from Iroquois traditions, Part II for certain only choreographically. Parts I and IV fit into the picture, especially the latter into the more archaic patterns. Part VIII advances three good arguments for influence from the popular Iroquoian "Fish-type" style.

2. The Tutelo could by this formal testimony claim Parts II, III, VI, and VII as their own. Before conceding this or possible Iroquois influence in the other sections, it is necessary to follow the rite backwards on the long trek from the southern homeland.

The late Tutelo chief John Buck stated that "Four Nights Songs are still sung in the same way as they used to be done."[12] Used to be done when? Printed records go back only fifty years. Herzog transcribed two of John Buck's recordings,[13] of which No. 8 is almost identical with our No. 34. Cringan transcribed an Iroquois version of 8 songs, selected from our 31–40, and essentially similar to these.[14] Simultaneously, at the turn of the century David Boyle described the Four Nights Dance as "really a series of dances, for the music and steps changed frequently," just as today, but it "was engaged in by men and women"—not as today, either because of faulty observation or because the personnel has changed.[15]

Four Nights Dance has been incorporated into Iroquois harvest rites since 1848. Between that date and the Revolutionary War it was celebrated in a separate longhouse on adjacent Tutelo Heights, evidently in combination with several Iroquois dances.[12] Tutelo membership in the Cayuga Wolf clan dates back to their temporary Pennsylvania residence in 1753. As we retrace their migrations back to Virginia, their trail and their very identity become ever vaguer. Mooney established them and their twin tribe, the Saponi, on the Roanoke River in 1671,[16] in a fine and prosperous location. In their Piedmont homes the Saponi had no special longhouse or "state house," according to John Lawson, who visited them in 1701.[17] This observation agrees with the archaeological discoveries by Joffre L. Coe, who in a verbal communication and in a paper described their villages of circular homes without a square or temple. This again would agree with John Buck's account to Speck regarding performances in homes, a different one during each of four nights, with all-night dancing and a feast.[12] It contrasts with the elaborate council houses and ceremonial grounds of neighbors, such as the Cherokee and Creek, and of the Sioux west of the Mississippi.[17] Despite continuous contacts with these and even more with the southerly Tuscarora and the Shawnee to the north, the Tutelo maintained a conservative and independent culture pattern.[18]

3. Nevertheless, it pays to examine and compare the song and dance styles of neighbors and linguistic relatives, wherever fragments are available. The outcome may be condensed into a few words, for details can be found in previous publications by the writer and in references appended thereto.[19] All these tribes performed first fruit and harvest ceremonies, lasting four days on square grounds (Creek and recent Cherokee), to seven days on heptagonal grounds (seventeenth-century Cherokee).[20] Women had a special dance in all of them, on the fourth day. The "long dance" of the famous Creek busk appears to have been quite different from that of the Tutelo. However, Bartram described an eighteenth-century Cherokee women's step resembling the enskänye.[21] A similar step has been reported for the modern Shawnee Bread Dance. Both the Cherokee and Shawnee women

also use a double stomp step exactly like the Delaware Skin Dance and very similar to the Tutelo step. Cherokee women, and men too, make extensive use of gestures such as corn pouring during the Corn Dance.[22] The Cherokee also pair and cross over in several dances. Other Shawnee resemblances consist in a division of the Bread Dance into eight parts (alternately for women alone and for both sexes) and in the significance of the numbers 4 and 12.

Musically, the Shawnee appear closest. A Pumpkin Dance transcribed by Bruno Nettl from the Voegelin collection uses a 54 21 scale in mildly descending sequence.[23] The Cherokee also sometimes use sequence, but in a 7 5 3 1 scale. Creek songs use a period formation instead of sequence; that is, they contain statement and response. Such antiphony, which also prevails among the Cherokee and Iroquois, is absent in Tutelo music.

More musical similarities occur in Omaha songs across the Mississippi. A maize ritual song resembles the theme of Tutelo song 18.[24] Numerous songs show the 54 21 descending sequence, and particularly resemble Tutelo song 4. A few Omaha and Pawnee songs also use a 43 1 scale, but not in maize rites.[25]

In contrast with the rarity of this hybrid scale and of the "Tutelo step," the side shuffle and associated simple 5 3 1 tonality are virtually ubiquitous in older ritual songs of the Eastern woodlands. The counterclockwise circling also characterizes the rites of all tribes of this area. Here Tutelo and Iroquois shared in a widespread pattern, whereas Tutelo step and gesture appear Southeastern. But the stride and the song style of Parts III and VI so far have no equivalent.

Function as First Fruits Rite

With all their conservative tendencies, the Tutelo must be regarded as participants in a larger Southeastern cultural complex. Maize ritualism had reached impressive proportions, especially to the south. Yet even among the Creek it incorporated a hunt and animal dances.[26] Among the Tutelo, as among the Shawnee, agriculture never surpassed the hunt as a means of subsistence,[27] and first fruit rites would pay homage to beasts and wild crops as well as to maize. Actually, the name Four Nights Dance does not refer strictly to corn, and only Part III represents a harvest of corn, Part VI a harvest of wild fruits. The (rather doubtful) text translations more consistently involve crops. Regarded in the light of a first fruits rite, the stylistic peculiarities make sense by means of the following hypothesis:

1. The central archaic Part IV partook of a widespread, ancient substratum, possibly as animal first fruits rite. Part VIII might fit into this concept, despite the complex choreography, especially when we remember that among the Iroquois this ground plan is confined mostly to animal dances.

2. The more developed Parts I, II, V, and VII connect both musically and choreographically with tribes to the immediate northwest, the semiagricultural Siouan Omaha and, considerably more, the Algonquian Shawnee. Analogies with Iroquois songs select women's medicine and ghost rites. Inter-Tutelo analogies are confined to mortuary and regeneration rites. Cherokee resemblances are confined to dance steps. Though this fits into conclusions of archaeologists and historians of prehistoric and historic proximities,[28] yet it is best to refrain from premature suggestions concerning the heritage of these song groups.

3. Parts III and VI definitely serve as harvest celebrations. Their greater complexity points to a fairly recent period; their tonal uniqueness indicates local origin right there among the Tutelo, though not perforce simultaneously.

In contrast with the homogeneous Tutelo mortuary rites, Four Nights Dance thus might account for its accumulation of patterns by growth at different periods and under various influences. The sum total of forms gives several clues as to Tutelo culture: the importance of women, their share in food gathering and preparation of corn and unleavened bread, artistically a vigorous and precise, well-organized quality, a predilection for functional mime and for functional, repetitious, and unadorned designs, corresponding to the recovered artifacts. Traditions and facts indicate unostentatious, domestic ritualism, with dances accommodating their circular ground plans to the circular confines of the habitations.

In the southerly Piedmont climate the first green corn would have been celebrated not much later than the Creek busk, hence in July. The migration to northerly Ontario would synchronize this date with the time of strawberry harvest and would gradually delay the festivity to coincide with the harvest of that climate. This is, indeed, what has taken place.

Beyond these suggestions, further study of adaptation in dates, forms, and style will be left for another time. Conjectures require help from other cultural sciences. For the most part these must deal with the past. For the modern vestiges of the Tutelo tribe have lost not only their ancient homeland but also every trace of their material culture and social structure. They have clung tenaciously only to artistic elements of three splendid rites, and that because their one-time enemies, the Iroquois, have perceived the superior qualities of these works,

have admitted them to the longhouse, and have conscientiously reproduced both the familiar and the exotic forms. Despite inevitable changes and possibly additions, they have left the essentials intact. In this case the combined sciences of musicology and choreography must be called in from the periphery to contribute another chapter to ancient life in the American Southeast.

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THE MIGRATION

Day after day the birds are coming back
Under the turbulence of windy rain.
Through mountains where the sudden storms attack
The small wings northward find their way again.
The chilling hail swirled from unfriendly space
Is a hard thrust against them in the night;
But on their journey nothing will erase
The urge that gives them their instinctive flight.

There is a transient action in the sun:
A morning suddenly has birds and song.
They haunt the budding countryside and run
Through trees expanding to make shadows long.
As chains of cold loosen about the land,
They reappear—and then we understand.

DANIEL SMYTHE

Delanson, New York

The Tuatara: Why Is It a Lone Survivor?

CHARLES M. BOGERT

The author may well attribute his interest in herpetology to his early years in the American Southwest: He was born in Mesa, Colorado, and was educated at the University of California, Los Angeles, where he was a teaching assistant for two years. He has been at The American Museum of Natural History since 1936 and curator of the Department of Amphibians and Reptiles since 1943.

WHAT happened to the rest of the beakheads? It seems unbelievable that *any* beakhead managed to survive. Theoretically they should have become extinct about 135 million years before the dodo was even discovered. Strangely enough, the one surviving beakhead was made known to science almost exactly one hundred and fifty years after the dodo disappeared.

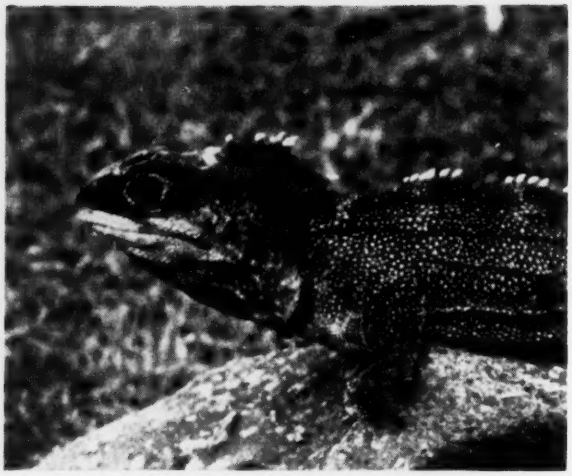
In 1831 when J. E. Gray[1] described the original specimen of the only existing beakhead, he scarcely realized that the reptile skull he had in his hand was anything very spectacular. The title of his brief paper indicates that he thought he had a lizard skull, but he says nothing concerning its source. He observed that there was an odd arrangement of the lower jaw in its attachment to the skull, which he said would "doubtless form the type of new genus, which [in allusion to the wedge-shaped teeth] I propose to call *Sphaenodon.*"

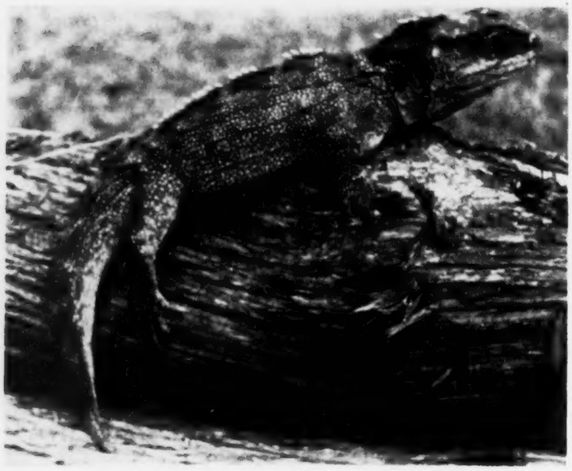
Eleven years later the good professor had virtually forgotten about the odd skull. When he examined some reptiles that a Dr. Dieffenbach brought back from New Zealand, he described two of them as new to science. Gray[2] placed one of these in the family that includes the common Old World lizards of the genus *Agama*. Not realizing that his specimen possessed a skull like the one he had examined over a decade before, he coined an entirely new name for the genus and supplied a name for the species, calling the creature *Hatteria punctata*. In a few terse phrases he described the external appearance of the reptile, adding a paragraph that consisted of three words, "Inhabits New Zealand."

To this brief description he appended some notes supplied by Dr. Dieffenbach, who had observed that the species "lives in holes, especially on the slopes of the sand hills of the shore. The older missionaries say it was formerly common, and the natives lived upon it, but for the last fifty years it has been scarcely ever seen. This specimen was found on a small rocky island, two miles from the coast, in the Bay of Plenty. . . . It is extremely sluggish in captivity, and could be handled without any attempt at resistance or biting." Still quoting Dr. Dieffenbach, Gray added, "The natives called it 'Tuatara.' "

These notes and descriptions produced no furor. In fact, they remained virtually buried for the next twenty-five years, when in 1867 Albert Günther,[3] of the British Museum, carefully examined some tuataras, both inside and out, and came up with the first really startling conclusion concerning this New Zealand reptile. Günther said it was not a lizard at all. Moreover, he pointed out that the term *Rhynchocephalus* (from the Greek *rynchos* "snout," and *kephalē* "head," roughly translated as "beakhead") had been applied to the same reptile by Sir Richard Owen[4]—the same man who coined the name "Dinosauria," incidentally. Furthermore, said Günther, these reptiles were so distinctive that they belonged in a separate order equal in rank to the crocodilians, the turtles, or to the group that contains both the snakes and lizards. Using Owen's name as a basis, he applied the name Rhynchocephalia to the new order.

Offhand, this verdict does not sound especially provocative. But it was enough to stimulate a stream of studies that continues down to the present day. Perhaps a hundred technical papers have been written about New Zealand's tuatara. Its bones, skin, tail, brain, teeth, muscles, and other organs have been examined, described, and compared with those of other reptiles. Its breeding habits and its development have been studied meticulously. Its rate of oxygen consumption and its heat production have been measured. Most biological texts mention the tuatara, and numerous





Two views of a tuatara (*Sphaenodon punctatum*), the only surviving beakhead, photographed on Little Barrier Island, Hauraki Gulf, New Zealand, in February 1948 by Robert Cushman Murphy. The eye is so dark that the elliptical pupil is not apparent except upon close examination.

popular articles have described it, often with misplaced emphasis on its "third eye."

Actually this vestige of an eye in the forehead of the tuatara is not so spectacular as many accounts would indicate. Externally the "eye" is rather easily seen in the hatchling as a small transluscent scale, but in the adult is it barely discernible. In fact, a photograph widely published[5] over a decade ago included a pencil pointing toward what was said to be the "third eye." In reality it indicated the location of what was apparently a scar slightly off to one side and much farther forward on the head.

It is quite true, however, that this "parietal eye," to use the technical term, does indeed contain some of the structures of an ordinary functional eye; in particular, a lens and a retina are present. Also the retina, the deeper layer of the eye that contains sensory cells, may be connected to the forebrain. At least there seems to be a connection in the hatchling,[6] although it may degenerate in the adult.[7] But there is no iris or similar mechanism to regulate the amount of light that reaches the sensitive layer. Since the parietal eye in fully grown tuataras is covered with skin, it is doubtful whether any appreciable amount of light reaches the retina.

In some true lizards there is a large transparent scale over the eye that corresponds to the cornea or the outer covering of the eyeball of normal functional eyes. Thus the parietal eye is far more conspicuous and even better developed in such American reptiles as the horned lizards, the fringe-footed sand lizards, or the ordinary anole (the false chameleon commonly sold at circuses). For that matter, all the structures found in the parietal eye of the tuatara have also been found[8] in the Australian stump-tailed lizard, even though other members of the family to which it belongs may lack even the hole in the skull that marks the location of the parietal eye in many lizards.

The really interesting aspect of the third eye lies in the fact that it is a remnant of a pair of eyes, one of which all but disappeared in ancient times. One eye is suppressed to develop as the pineal organ, believed by some to be one of the ductless glands. In lizards it is the one on the right side that is retained as the vestige of an eye;[6] in the tuatara it is the one on the left. It has been suggested that the purpose of this elementary eye was to warn the animal of the approach of an enemy from above.[7] Were there any evidence to indicate that an eye on the top of the head came into existence or showed signs of improvement as the flying reptiles or the birds evolved, this idea might be taken more seriously.

Repeated experiments have failed to prove that the parietal eye is of any real use either to the lizard[9] or to the tuatara. It has nothing to do with vision. Even though there are indications that the parietal eye of the anole is sensitive to light, other structures in the skin are of greater importance in this respect.[10] If heat is directed to the parietal eye it seems to be no more sensitive than the skin. The most that can be said is that, in some lizards that bask in the early morning, a transparent scale over the parietal eye might permit the sun's rays to warm the brain somewhat more rapidly than would be the case were the central nervous system completely covered with bone and skin.[9]

However, the discovery that the vestigial eye in the lizards and in the tuatara arises from separate parts of the original pair provides further support for Günther's belief that the New Zealand reptile is not a lizard. Günther pointed out several other differences that set the tuatara apart from the lizards, noting that in some respects it more closely resembles extinct reptiles, crocodilians, or birds.

Later studies have continued to bear out Günther's conclusions. One of the more interesting facts that have come to light concerns the nature of the "egg breaker" of the hatchling tuatara. After twelve or thirteen months of development within the egg, the fully formed young would be imprisoned within the leathery shell that has held it in protective custody were it not for a sharp spine on the tip of its snout. As the time for hatching approaches, moisture is absorbed by the egg until its shell becomes as tight as a rubber ballon. Thereupon the spine is brought into play. As soon as it punctures the shell, the entire end of the egg splits wide open and the young tuatara emerges, ready to dig its way to the surface.[11]

Close examination of the egg breaker, which falls off within a week after hatching, shows that the spine is a horny outgrowth from the skin—precisely the same sort of structure that occurs in turtles, crocodilians, and birds. Although this horny spine, more properly a caruncle, is commonly called an "egg tooth," it is only in the lizards and the snakes that actual egg teeth are found,[12] for the egg slitter of lizards and snakes is a real tooth made of dentine and attached to the bone. In some lizards two egg teeth are present, but whether single or paired, such teeth have razor-sharp edges that serve not merely to puncture the shell, but actually to slit it.

The presence of a caruncle in the tuatara suggests that it is less lizardlike than one might expect from its outward appearance. But its habits are not appreciably different from those of other existing reptiles. It does have special breakage planes in its tail, which can be regenerated when lost.[13] In this respect it is like most lizards and unlike turtles, crocodiles, or snakes, all of which remain stumped-tailed if a predator nips off the rear end.

Like the crocodilians and some lizards that are active at night, the tuatara is equipped with vertically elliptical pupils and a voice, but its call is in no way similar to the roar of an alligator; nor does it resemble any of the various sounds—squawks, chirps, or whistles—produced by the nocturnal lizards called geckos. On the contrary, the call of the tuatara is a croaking noise, more nearly comparable to that of some frogs.

The time required for the incubation of the tuatara's eggs is abnormally long for a modern reptile, but even in this respect it is approached by some turtles. Furthermore, the eggs of the tuatara, scarcely an inch long, are extraordinarily small for a reptile that commonly attains a length of two feet. The egg of a Gila monster of similar dimensions would be over twice as long and several times as bulky. It is quite evident that the eggs are fertilized internally, as they are in all reptiles, but another important difference that distinguishes it from all modern reptiles turns up here—the male tuatara lacks any apparent means of inseminating the female.

Despite peculiarities that show rather conclusively that New Zealand's famed reptile is not a lizard, there is nothing outwardly spectacular about the tuatara. Superficially it resembles such lizards as the larger iguanas of the American tropics or several Old World lizards, in having a row of horny spines on a ridge down the middle of the back. Even though exceptional specimens are reputed to reach a length of thirty inches and to weigh over two pounds, the tuatara would not be regarded as large among such contemporary reptiles as marine turtles that weigh over three quarters of a ton, twenty-foot crocodiles that may weigh even more, or snakes that may reach a length of thirty feet.

Today the tuatara is restricted to a tiny fraction of the earth's surface, a score of small islands off the coast of New Zealand in Cook Strait and the Bay of Plenty.[14] The Maori were doubtless the first people to see it, and they took some interest in it, noting that it was edible. Today it is of no economic importance. Why, then, should this reptile attract so much attention? The answer lies in the eventual realization that the tuatara is a relict, a living fossil—another way of saying that it is the lone survivor of a group of animals that had its heyday in the distant past. For the animal to which Owen applied the fancy Latinized Greek name meaning beak-head should have been a fossil—a creature that had died millions of years before Owen examined its bones. Why, one may well ask, does a relict warrant such extensive study? One answer lies in the fact that by learning all we can about such relicts we can hope to find some way of accounting for the extinctions of the larger reptiles. Entire groups, including all the real giants, faded from the scene during Cretaceous time or even earlier.

When the dinosaurs still roamed the earth 150

million years ago, the ancestors of the tuatara were their unimpressive neighbors. The dinosaurs rapidly—at least to the geologist—expanded into a multiplicity of forms and then disappeared from the face of the earth. The relatives of the tuatara evidently underwent little change, at least in their bony structure, despite the fact that they managed to out-survive the dinosaurs. But from what evidence we can piece together it was a precarious survival. Had the tuatara not reached a distant outpost, it might well have preceded the dodo into oblivion. But did this odd reptile manage to hold on in New Zealand because no important enemy existed until man eventually appeared, bringing along dogs, cats, and the inevitable rats? Or was it New Zealand's climate that saved it?

Before attempting to answer these questions we need to know something of the tuatara's history, its relatives, and their reputations as world travelers. The tuatara, as one of the rhynchocephalians, has a fossil record that is evidently incomplete; but it suggests that the beakheads never loomed very large in the evolutionary stream. Despite the present-day existence of the tuatara, not one bone identifiable as that of a beakhead has been discovered in the rocks laid down since the early Cretaceous period,[15] some 135 million years ago. The few skeletal fragments left behind in still older rocks suggest that the beakheads branched off the same stem that later gave rise to the dinosaurs, as well as to the crocodilians, lizards, and snakes. But while other branches of this stem were developing into birds, and the mammals were descending from an even earlier offshoot of the main reptile stock, the beakheads seemingly never gave rise to anything except more beakheads.

In all probability the ancestral lizard was, like the dinosaurs, a contemporary of some of the early rhynchocephalians. The turtles were present, and it is likely that they already had acquired many of their distinctive characteristics, including the armor that has seemingly led to their persistent but otherwise limited success. However, the beakheads were past their peak and approaching their decline before the turtles, crocodilians, lizards, or birds began to flourish.

That the beakheads attained a small measure of success is attested by the fact that some 200 million years ago there were several kinds and that some of them spread over much of the world. Their remains have been found in deposits laid down in ancient times in Africa, Europe, the Americas, and Asia.[16] Possibly the ancestral tuatara reached New Zealand by way of Australia, despite the fact that no beakheads, either fossil or recent, are known from that continent. Or perhaps Australia was bypassed, and the beakheads, by dint of a little swimming, got to New Zealand over a circuitous route represented by a chain of islands, now widely separated, that extends from New Guinea through New Caledonia, and swings southward to include Norfolk Island. This tiny island lies between New Caledonia and New Zealand, with about five hundred miles of ocean separating the two. New Zealand lies even farther from Australia or Tasmania, with over a thousand miles of ocean in between.

It is not difficult, of course, to account for the presence in New Zealand of bats that fly and of marine mammals so obviously able to swim; such flightless birds as the kiwi and the moa descended from winged ancestors.[17] But it is doubtful whether we shall ever learn precisely how the tuatara reached the islands. Possibly there were no warm-blooded animals in existence when it accomplished the feat, for the ancestors of the birds and mammals may not yet have had the mechanisms for internal heating. In any event, it is generally believed that land-dwelling mammals did not reach New Zealand until man belatedly arrived.

Snakes were abundant in Australia, and a few got to New Caledonia, six hundred miles or so off the east coast. Nevertheless, they never succeeded in reaching New Zealand. Several geckos and skinks did, but these lizards secrete themselves in man's boats and other belongings and turn up in virtually all the tropical or temperate oceanic islands inhabited by man. Those surviving in New Zealand, however, must be able to tolerate a relatively cool climate.

New Zealand, in almost the same latitude as Patagonia, lies as far from the equator as New York, but its climate is relatively cooler, with its warm season more like that of Newfoundland in summer. Owing to the tempering effect of the surrounding waters, its winters, on the other hand, are similar to those of the American Gulf Coast. Days when a reptile might bask in the sunshine are limited in number. Cloudy, overcast days are more numerous, for the rainfall of New Zealand equals that of the wettest parts of temperate North America. Portions of the islands at lower elevations have twice the rainfall of New York, and in the highlands the rainfall is considerably heavier, amounting to more than 200 inches.

It may be of considerable significance that the tuatara survives in a region so cool that it would be shunned by most modern reptiles. It is further noteworthy that lizards become abundant in the fossil

Adult tuataras in the group at The American Museum of Natural History in New York. Until 1952, when zoological gardens in San Diego, Chicago, and New York each obtained a live specimen, the tuatara was known to most Americans only as a living fossil depicted in textbooks. Although superficially lizardlike, several anatomical and physiological peculiarities mark it as the sole survivor of the order Rhynchocephalia, most members of which became extinct 135 million years ago.

record at approximately the same time that the ancestors of the tuatara disappear. On the whole, lizards seem to have replaced the tuatara and its relatives. Or the increase in the numbers and kinds of the heat-loving lizards may have been brought about by the same factors that resulted in the near disappearance of the beakheads.

Several lizards occupy the islets now inhabited by the tuatara, and apparently they do not interfere with it—indeed, they may be preyed upon by the tuatara. There were tuataras on the main islands when the first Europeans arrived, as Dr. Dieffenbach's account notes. Soon afterward, with the introduction of hogs, cats, and rats, the tuatara probably became exterminated on the larger islands. As recently as 1940 occasional tuataras are said to have been seen in the more inaccessible parts of the main islands,[5] but these reports remain unverified. It is altogether probable, therefore, that the tuatara's presence on the islets at first uninhabited by cats, rats, and pigs saved it from extinction.

On Stephen Island the later introduction of the domestic cat might well have finished off the beakhead population had steps not been taken to destroy the cats. In 1899 a report stated that several dead tuataras partly eaten by cats had been found. Fortunately the New Zealand government employed various means of eliminating the cats, and the methods seem to have been effective—at least the tuatara population on Stephen Island appears once more to be thriving.[18]

Quite aside from the late entry of cats into the picture, circumstances suggest that in other parts of the world the evolution of mammals might have played a part in the near extinction of the beakheads. We may also infer that the ancestral tuatara reached New Zealand before either the mammals or the lizards began their major expansion. If we consider the almost disastrous effects of the advent of mammals in New Zealand in relatively recent times, there can be little doubt that the tuatara would not have survived until the present had it not reached this remote asylum well ahead of the mammals.

Other questions remain unanswered, however. Were the ancestral beakheads inhabitants of regions as cool as New Zealand? Or did the tuatara gradually acquire the ability to live under such conditions?

The tuatara is sometimes cited as a remarkable case of evolutionary stagnation.[15] The skeleton of a reptile found in the Jurassic deposits of Europe is so nearly identical with that of the living tuatara that very little change in the bony structure must have taken place during a period of 150 million years. This suggests that the ancestors of the tuatara were not especially plastic—their stock did not produce any modifications, at least in the bones, that might have been necessary for survival under specialized conditions. It is not necessarily a reliable inference, but reasons might be advanced for the belief that the ancestral tuatara lived under climatic conditions similar to those of its surviving descendant.

It seems probable that in the ancient past climates throughout the world were more nearly uniform than they are today. There is evidence that the zoning of climates began to become more pronounced about 60 million years ago. It cannot be established with certainty whether there was a trend toward increasingly warm climates following the demise of the dinosaurs, but this has been suggested. In any event, no one who is familiar

with the evidence doubts that there have been numerous climatic changes. Geologists find good evidence of widespread glaciation during the Permian Period over 200 million years ago, and we are, of course, now emerging from the great glacial epoch in which an ice sheet covered much of Canada and portions of the United States.

But was it generally colder during the time of the dinosaurs than it is now? It is extremely difficult to find any real proof that it was, but Raymond B. Cowles,[19] of the University of California at Los Angeles, has suggested that increasingly hotter climates may have been a factor of major importance in the disappearance of many reptiles during the great crisis near the end of the Mesozoic era 60 million years ago.

Cowles further points out that the descendants of reptiles, whose ancestors were living alongside the dinosaurs, can be sorted into three classes. First, there are the smaller species, particularly the lizards that escape the heat by burrowing, seeking crevices, or by emerging only at night. Second, there are the crocodilians and the marine turtles, the largest reptiles that still survive, but perhaps only because they take advantage of relatively large bodies of water, which never attain the high temperatures of the land. Finally, he points out that it was the warm-blooded mammals and birds that really began to flourish as the large reptiles began their rapid decline.[20, 21]

We may never know when the birds and mammals reached their present warm-blooded state. We do not have the vaguest notion when fur came into existence, but we do know that feathers were present on birds that were still reptilelike during the Jurassic. Some sort of insulating coat was necessary, it is assumed, before an animal would find it advantageous to utilize energy for internal heating. Did warm-bloodedness precede the feathers or the fur?

Professor Cowles doubts that it did. A man forced to spend his summers in Death Valley might well build himself a well-insulated house to protect himself from the heat. Finding that he had to spend a winter there, he would doubtless be pleased to realize that insulation had its virtues during the cold period when he had to rustle wood for his fireplace. Cowles[22] suggests, therefore, that fur and feathers came into existence because such body coverings afforded protection from increasingly greater amounts of heat that reached the earth from the sun. At first such insulation merely permitted these animals to engage in more extended forays in search of food. When the sun approached the zenith the animals with overcoats could remain abroad when the others were forced to retire—if they could burrow or find shade. Later, having become well endowed with fur or feathers, the birds and the animals were better equipped to acquire and to perfect the internal heating mechanisms that led to warm-bloodedness.

Thus, if Cowles' speculations are correct, the smaller reptiles, the shore-dwelling crocodilians, and the insulated birds and mammals might have been well prepared to tolerate increasingly hotter climates when the dinosaurs could not. For bulky land dwellers would have found it difficult to remain abroad long enough to nourish their huge bodies and still avoid overheating. What was worse, it would have been impossible for them to burrow, and difficult for them to find suitable shelter.

Since we cannot experiment with dinosaurs, we are forced to base any assumptions concerning their heat tolerance on what we can learn from their nearest surviving relatives. The crocodilians are descended from a stock that also gave rise to the dinosaurs, and we find that alligators die if their body temperature rises much above 100° F.[23] In contrast, some lizards are habitually abroad with temperatures as high as 107°,[24] and for short periods nearly all snakes and lizards can withstand body temperatures of 104°, or even higher.

Thus, without having recourse to oceans, lakes, or rivers, the crocodilians would stand little chance of surviving in regions where high temperatures prevail during any part of the year. Indeed, they are absent from all deserts except those traversed by such large rivers as the Nile. Furthermore, even though crocodilians bask, they do most of their feeding at night, after temperatures have dropped.

If the dinosaurs were no better able to tolerate high temperatures than the crocodiles and alligators, they may have encountered severe problems with increasingly hotter climates. We do not know whether dinosaurs were adapted to forage at night, but there are good reasons for believing that many of them were land dwellers, like the beakheads. Consequently, there are advantages in learning something of the heat requirements of the beakhead surviving in New Zealand, more especially since its relatives in all other parts of the world came to the end of their rope at very nearly the same time that the dinosaurs did. It was with this idea in mind that I asked Robert Cushman Murphy to take along some special thermometers when he generously offered his services as he was about to set out in 1948 for the Pacific Science Congress in New Zealand. There Dr. Murphy met Karl P. Schmidt, chief curator of zoology of the Chicago Natural History Museum, who was also attending

the congress. Having devoted most of his career to the study of reptiles, it need scarcely be added that Dr. Schmidt planned to see tuataras in their natural habitat.

To do so he arranged to go to Stephen Island, long famed among the islets in Cook Strait as a sanctuary for the living fossil. When Dr. Schmidt set out in February he was accompanied by William H. Dawbin, a competent zoologist from New Zealand's Victoria University College. Learning that we needed a series of temperatures, Mr. Dawbin returned to the same island in April, and again in November, when he stopped briefly at Trios Island en route. On these two trips Mr. Dawbin managed to obtain temperatures of 76 tuataras.

This entailed considerable work at night, since we wanted to know what range of temperatures the tuatara tolerated while it was abroad and active. During the daylight hours it rarely ventures far from its burrow. It may bask at the entrance on sunny days, but if the day is overcast it is unlikely to be seen.[25] It comes forth to feed principally at night, and probably its mating activities, which have never been observed, are also carried on in darkness. Mr. Dawbin was forced to search for tuataras between sunset and midnight, often when it was too cold for comfort, with air temperatures rarely above 55° F. Even so, the tuataras were evidently foraging actively, and in November they may have been depositing their eggs. Despite the time required to record temperatures, not only of each reptile but of the air and the ground where each individual was taken, Mr. Dawbin caught as many as 24 tuataras in a single evening.

Knowing that the tuatara inhabited a moderately cool region, we expected it to tolerate low temperatures. Nevertheless, we were not wholly prepared for the results obtained by Dawbin. The highest body temperature he recorded for an active tuatara was 56° F., and some were engaged in their normal pursuits when the body was only 11° above freezing. The average temperature of active tuataras was just under 52° F. These are not temperatures of modern reptiles! Of thousands of reptiles captured in the deserts, plains, and mountains of the United States, or in the cool cloud forests on the summits of old volcanoes in the American tropics, none has ever been found abroad and moving with a body temperature lower than 58° F. The one snake with this temperature was quite possibly caught off base the night we found it in the foothills of California, for air temperatures had suddenly descended as a storm moved in from the north.

Such amphibians as toads maintain the body at a mean level of 76° F., but temperatures like those of the tuatara are encountered among land-dwelling backboned animals only in salamanders living in spruce forests on mountaintops. Reptiles are a notch above the amphibians in the evolutionary scale, but perhaps the tuatara actually retains characteristics of its primitive moist-skinned ancestors.

Experiments carried out in New Zealand by R. D. D. Milligan[26] indicate that the tuatara has an extremely low metabolic rate, or "rate of living," lower than that of turtles or lizards. As a matter of fact, the chemical changes in the cells that provide the energy necessary for the vital processes within the body of the tuatara are evidently carried on at a considerably lower rate than in frogs at similar temperatures. One tuatara at a temperature of 48° F., manifestly warm enough to be active, showed no sign of breathing during an entire hour that Dr. Milligan watched it.

We need scarcely wonder that the tuatara can subsist on two snails or a few crickets per day, or that it spends most of its time motionless. It is this behavior (or the lack of it) that causes it to be described as sluggish. Nevertheless, it can and does move fairly rapidly for short distances.[25] We may well doubt that it is capable of any sustained activity, even less than most reptiles, and none of them compares with the mammals or birds on this score. The tuatara's low rate of living is doubtless coupled with its limited heat requirements, and it may have reached New Zealand at a time when reptiles not only tolerated but required low temperatures.

Turtles have their protective armor, and many reptiles rely upon their secretive habits, hiding to avoid the heat as well as their enemies. However, lizards that are active and living in open country during the day avail themselves of heat provided by the sun to raise the body temperature. Reptiles that regulate their body heat by basking are as warm-blooded as their avian or mammalian enemies—and move virtually as fast. True, they are forced to seek shelter when the sun fails to shine or when air temperatures drop, but since they are not using energy to keep the body warm, they require only a fraction of the food that a bird or a mammal must consume merely to remain alive.

As for the beakheads, if they were at all like the tuatara, they foraged at night. Adapted for this sort of existence, and perhaps with eyes modified for vision at night, they could not avail themselves of direct sunlight to raise the body temperature and increase their speed. When the mammals began to appear on the scene the beakheads were no match for them. So we can attribute the tua-

tara's survival in remote New Zealand to a combination of factors. The cool climate suited its low rate of living, and until historic times no mammals arrived to molest it.

What happened to the rest of the beakheads? We shall never know for certain. Nevertheless, Professor Cowles may be quite correct in his belief that increasingly higher temperatures contributed to their extinction as well as to that of the dinosaurs. In view of the fossil record it seems probable that the beakheads in other parts of the world preceded the dinosaurs into oblivion. It may have been not so much because they could not withstand the heat, but because they failed to avail themselves of its advantages. Had the beakheads been able to follow the course taken by the lizards, they might well have adopted a means of regulating their body temperature. With warmer bodies they would have been able to move fast enough to escape the mammals that began to appear. It was largely a matter of the tuatara's good fortune that the mammals arrived too late to catch the boat for New Zealand.

Perhaps the tuatara could be compared to the village centenarian. He may have no particular virtues, either physical or mental, but he has outlived all his former contemporaries—more than can be said of the poor old dodo, despite its acquisition of internal heating.

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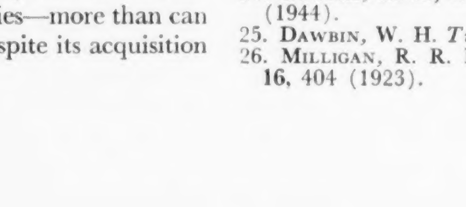

SCIENCE ON THE MARCH

POTATO INSECT PESTS IN THE BOLIVIAN ALTIPLANO*

ON THE Bolivian Altiplano, a high plateau 12,500 feet above the sea, extending for hundreds of miles between the eastern and western mountain ranges of the country, the potato continues to be grown in probably much the same manner as in ancient times. The Altiplano is one of its ancestral homes.

Fortunately some of the more serious insect pests that attack potatoes in Bolivia do not appear to have accompanied the crop when it was introduced into other parts of the world. To what extent these stay-at-home pests could become established elsewhere is a moot question. The chances are that they would be just as troublesome as in their native habitat. It is well to know their power and to strengthen, insofar as possible, all safeguards against their spread.

The insects that, according to the author's observation, caused most serious damage to potatoes on the Altiplano during the past season are listed in Table 1.†

Premnotrypes sp., commonly known as *gusano blanco*, is by far the most damaging to potatoes in this region. Its larvae, or grubs, invade 30 per cent or more of the tubers and make them unfit for any purpose except possibly as feed for livestock. A survey of potato fields in the Lake Titicaca vicinity during harvesttime in 1952 showed from 18 to 59 per cent of the tubers to be infested with the pest; average infestation was 34 per cent. Growers said their potatoes were damaged to about this extent every year. The pest is widespread in the region.

Usually there are 5–10 larvae in each infested tuber, but the number may be even higher. The writer noted 29 in a single potato, and one grower who had a heavily infested field had counted as many as 47 in one tuber. When the larvae have consumed the contents of one tuber, they invade others nearby.

This insect appears to have an annual generation or life cycle. After the potatoes have been harvested, heaped on the ground, and covered with dry grass for winter storage, the mature larvae either remain in the tubers or bore into the soil beneath, where they gradually complete their transformation in time to emerge as adults and lay their eggs on the next crop of potatoes.

Growers endeavor to cull the damaged tubers before marketing the crop, although doing so involves a great deal of hand labor. Even so, many damaged tubers escape notice, and the consumer must remove the larvae before cooking the potatoes.

At maturity the larva is white and stout-bodied, with a brown head, and is about 8 mm long. The adult is a dark-brown, stout-bodied beetle, about 6 mm long.

Indian farmers place layers of a native mintlike plant called *khoa* in the winter storage heaps of potatoes, on the assumption that it drives the larvae out of the tubers. Arnaldo Sanjines A. de Leon and Julio Rea, of the Servicio Agrícola Interamericano Experiment Station near Achacachi, and Gordon Barbour, a prominent grower near Huatajata, express the belief that the practice merely serves to console the farmer and has little

TABLE 1

Order	Family	Species	Common Name
Coleoptera	Curculionidae	*Premnotrypes* nr. *latithorax* (Pierce)	*Gusano blanco*
Lepidoptera	Gelechiidae	*Gnorimoschema operculella* (Zeller)	Potato tuber worm
Lepidoptera	Phalaenidae	*Copitarsia consueta* (Wlk.)	*Ticona*
Diptera	Anthomyiidae	*Hylemya cilicrura* (Rond.)	Seed-corn maggot
Thysanoptera	Thripidae	*Frankliniella tuberosi* Mlt.	Thrips

* A contribution from the Servicio Agrícola Interamericano, a technical agricultural service organization for Bolivia, operated jointly by the government of Bolivia, the Office of Foreign Agricultural Relations, USDA, and the Institute of Inter-American Affairs. U. S. participation in this work was carried out as part of the Point IV Program in Bolivia, administered by the Technical Cooperation Administration, U. S. Department of State.

† Appreciation is expressed to the Division of Insect Identification of the U. S. Bureau of Entomology and Plant Quarantine, Washington, D. C., for insect identifications, and to Bolivian technicians Julio Rea and Walter Rodriguez for assistance in this study.

Two potato tubers cut open to show injury caused by *gusano blanco* (*Premnotrypes* sp.). (Photo by Frank J. Shideler.)

practical value. Many of the maturing larvae normally leave the tubers at harvesttime or during storage, and the device probably does very little to speed their departure.

Copitarsia consueta (Wlk.), referred to by the local growers as *ticona,* is another serious pest in some years. At times it causes damage not only to potato tubers but also to quinua (*Chenopodium quinoa*), another important food crop of the Altiplano.

The larva of ticona sometimes resembles the common garden type of cutworm, both in size and in appearance; the moth is mottled-brown and robust, and has a wing expanse of about 45 mm. The larva burrows deep into the ground to gouge the tubers, thus making the potato unfit for table use. Usually only one larva is found in a single tuber.

Among other potato pests are the adults of the seed-corn maggot *Hylemya cilicrura* (Rond.). These were collected in fairly large numbers with an insect net during the 1952 growing season, but at the close of the season only the maggots were to be found. The maggots were present in large numbers in potato "fruits" that were still clinging to the frozen vines or had dropped to the ground. Apparently the pest survives the winter in this manner. In cool, backward seasons these maggots cause damage to newly planted seed potatoes.

Thrips, *Frankliniella tuberosi* Mlt., do their damage by feeding on the foliage of the potato plant. During the early part of the past growing

Much of the cultivation carried on by the Indian farmers of the Bolivian Altiplano is done with primitive hand tools. (Photo by Robert O. Blodgett.)

The author inspects potatoes heaped on the ground with protecting cover of dry grass for winter storage. (Photo by Frank Shideler.)

season the orange-colored nymphs were most abundant, but as the season advanced the dark-colored adults predominated. These tiny insects feed by piercing and rasping the leaf tissue, and the injured foliage takes on a rusty or browned appearance. The thrips were abundant also on the potato fruits after the first killing frosts, and it is probable that they spend their dormant period there. One of the large growers in the Titicaca region, who has controlled these thrips by a well-timed spray of DDT—at the rate of 3 lbs. DDT/hectare—said that when the insects are uncontrolled they can cause a 20 per cent reduction in tuber yields.

The foregoing pests constitute the main insect problems of potato growers in the Bolivian Altiplano. Of these, the seed-corn maggot (of European origin) and the potato tuber worm are widespread in the world. Only the maintenance of adequately enforced quarantines, based on sound biological principles, can halt the dispersal of the others. With our modern rapid means of transportation, the danger of spreading these and other agricultural pests is becoming ever greater. Already there is a long list of destructive insects that are firmly entrenched in the Americas—insects that were unknown there less than 100 years ago.

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ECONOMY OF DOUGLAS FIR IN THE PACIFIC NORTHWEST*

ECOLOGICALLY speaking, forest economics is concerned with the relationships between forests and human beings. The economics of Douglas fir, then, consists of two phases: the influence of *Homo sapiens* L. on Douglas fir (*Pseudotsuga taxifolia* [Poir.] Britton), and the influence of the species Douglas fir on man.

As to the first phase, a great deal has been said about how man has been the worst enemy of the Douglas fir forest, through fires, destructive logging, and clearing of steep or poor land for agriculture. Fortunately, human beings are beginning to learn to work with nature in the management of Douglas fir forests. No more need be said now on this phase of the economics of Douglas fir.

Concerning the second phase, it should first be pointed out that Douglas fir has significance or value to man only through the satisfactions, products, and services that it yields or is capable of yielding.

Douglas fir, as a species, as a forest, or as a material, means different things to different people. It is variously considered as an obstacle to agriculture (a stubborn type of woody vegetation occupying land needed for growing field crops or for pasturing livestock), a raw material for industry, a useful (and at times exasperating) building material, a base for employment, a tax base, a resource to be depleted, developed, or conserved, a forest furnishing a habitat for fish and game, or an environment for camping, hiking, picnicking, and communing with nature. To many, the Douglas fir forest is, in the fullest sense, a genuine source of

* For editorial consistency in a general scientific journal, the editors must follow general usage—specifically Webster—rather than the specialized terminology of the several scientific fields. They are aware of the fact that foresters have officially introduced a hyphen in Douglas fir to distinguish it from the true fir (*Abies*).

Poles and pulpwood are removed in stand-improvement thinnings from a managed second-growth Douglas fir forest, Crown Zellerbach's Columbia Tree Farm, Oregon. (Photo by Harold M. Brown.)

inspiration and of recreation. Those who are concerned with flood prevention, regulation of stream flow, the water supply, or soil and water conservation will be interested in Douglas fir as an important component of the ground cover, to some extent, in every state west of the Great Plains.

Detailed consideration will be limited here to the timber resource aspects of Douglas fir and to some problems of the business of growing, harvesting, and utilizing crops of Douglas fir trees. Although the Douglas fir region includes much of British Columbia and a portion of the Coast Range of northern California, the area we shall refer to as "the Douglas fir region" will be only that portion of the states of Washington and Oregon lying west of the summit of the Cascade Mountains.

Importance of Douglas Fir to the Economy of the Pacific Northwest. Eighty-three per cent of the land lying between the Pacific Ocean and the summit of the Cascades is forested or is chiefly suited to forestry and not otherwise used.[1] Were it not for the large agricultural areas in the Willamette Valley and the Puget Trough, the forest land would be 89 per cent of the total. On the basis of area alone, therefore, forestry is at least fully the equal of agriculture in economic importance to the Douglas fir region.

After excluding all forest land not capable of producing timber of commercial quality and all land withdrawn for special uses, such as national parks and wilderness areas, there remain 26 million acres of commercial forest land which comprise 77 per cent of the total land area of western Washington and 70 per cent of the total land area of western Oregon.[1] Sixty-one per cent of the sawtimber volume of the region is of the one species, Douglas fir.[1]

In 1950, forest products provided 57 per cent of all the freight carloadings in Washington and Oregon.[2] Each year the forest industries of the Douglas fir region make up about 60 per cent of the industrial payroll of the area.

Dependence of the United States on Forests of the Douglas Fir Region. Since World War I, the

Pacific Northwest has been the leading producer of lumber in the United States. Washington was the leading state until 1938, when Oregon assumed the leading position. In the past few years California has edged out Washington for the second position in national lumber production, a change which was due in part to a greatly accelerated rate of cutting in California's Douglas fir region since 1947. Eighty per cent of the annual cut from Oregon and Washington is from the Douglas fir region.[1]

In the year 1950, 10.7 billion board feet of lumber, or 31 per cent of the nation's total production, came from the Douglas fir region; of this amount, 10.6 billion board feet were softwood lumber, constituting 39 per cent of the nation's total softwood production.[1]

In 1950, of the lumber produced in the Douglas fir region of Washington and Oregon, only 19.5 per cent was marketed in these two states; 3.0 per cent was exported, and 77.5 per cent went to other states. Some of the details on the shipments to other states are significant: 9.4 per cent went to California by rail and truck, 23.3 per cent went to various states by water (mostly through the Panama Canal), and 44.8 per cent went by rail to other states, principally in the Midwest and Northeast.[3] In the same year the Douglas fir region of Washington and Oregon produced at least 70 per cent of the nation's veneer and plywood, and at least 16 per cent of the wood pulp.[4]

The Douglas fir region of Washington and Oregon, in 1944, had only 5.6 per cent of the commercial forest area of the United States, but 32 per cent of the nation's volume of standing timber, and 14 per cent of the country's potential growth capacity.[1] (The entire eastern half of the United States has 77 per cent of the commercial forest area, but only 35 per cent of the volume. The Southeast alone has 40 per cent of the area, 21 per cent of the volume, and half of the U. S. growth capacity; so it is an important competitor of the Douglas fir region.)

Forest Conditions in the Douglas Fir Region. In western Washington and Oregon the land now forested consists mainly of land that is too rough, too steep, or otherwise not well suited to agriculture or other higher use. Except in the flatter por-

Staggered settings in Douglas fir timber, on Iron Creek drainage, Gifford Pinchot National Forest, Washington. Patches of 30–40 acres are clear-cut, leaving surrounding stands to reseed the cutover areas. After new stand is well established, adjoining patch will be clear-cut. (Photo by U. S. Photo Service.)

After a severe windstorm, this entire area on Crown Zellerbach Corporation's Clackamas Tree Farm in Oregon consisted of scattered and broken standing trees and a large number of windfalls. All merchantable wood is being removed. (Photo by Don Baisinger.) Below, a helicopter is used to reseed a Crown Zellerbach tree farm. Cost of reforestation by this method, including expense of sowing poisoned grain or tree seed to destroy rodents, is often much less than the cost of planting. (Photo by Harold M. Brown.)

tions of the Willamette Valley there is very little land that is likely to shift from forest to agricultural use. On the moderately steep slopes of hills and in shoestring valleys there are many tracts where there is some question as to whether the best use would be grazing or timber growing. Such areas need further study.

One of the least satisfactory things about forest conditions in the Douglas fir region is the ownership pattern. According to P. L. Buttrick,[5]

> The prize example of a complicated and uneconomic forest ownership pattern is found in western Oregon, where a great number of small holdings and a small number of very large ones are mixed indiscriminately with both large and small public holdings under four distinct administrations, and all boundaries are based on a rectangular survey having no relation to topography.

In Washington the patchwork pattern is simplified only by the absence of revested railroad grant lands and the presence of a little more consolidation. Needless to say, such a pattern as that described by Buttrick results in numerous problems of access, timber trespass, and administration.

In western Oregon most of the federally-owned forest lands are administered by the Forest Service of the Department of Agriculture; but part of them, often intermingled with or actually overlapping Forest Service lands, are under the jurisdiction of the Bureau of Land Management of the Department of the Interior. Neither agency receives appropriations for local units that are directly proportional to the amount of timber sales activity.

The ownership of commercial forest land in the Douglas fir region, as of January 1, 1945, is shown in Table 1.

TABLE 1

PERCENTAGE OF OWNERSHIP OF COMMERCIAL FOREST LAND IN THE DOUGLAS FIR REGION

Federal and Indian			
National Forest	29.5		
Indian	0.9		
O & C, revested, etc.	7.8		
Unreserved public domain	0.9	39.1	
State, county, and city		10.1	
Total public			49.2
Private			
Large (over 50,000 acres)	14.2		
Medium (5000–50,000 acres)	6.7		
Small (0–5000 acres)	29.9		
Total private			50.8

Approximately one fourth of the land in small ownerships is in farms; much of the remainder is absentee-owned.

The present forest management of lands owned by the public and by large private companies is mostly good. The management on the small private holdings is mostly poor and destructive; yet much of the potentially most productive land is in these small holdings. Here is the heart of the forest problem.

The cover condition of the Douglas fir region and the total volume of standing timber are shown in Table 2.

TABLE 2

COMMERCIAL FOREST AREA (AND VOLUME) BY COVER CONDITION AND OWNERSHIP, DOUGLAS FIR REGION
(Areas in millions of acres; volumes in billions of board feet, log scale)

Condition	Public: Washington	Public: Oregon	Private: Washington	Private: Oregon	Totals: Douglas fir Region
Virgin	2.2	4.1	1.3	1.7	9.3
Second growth	0.5	1.4	0.7	1.1	3.7
Poles	0.5	1.3	1.4	1.3	4.5
Seedlings	0.7	0.6	1.2	0.5	3.0
Denuded	0.6	1.0	2.1	1.8	5.5
Totals	4.5	8.4	6.7	6.4	26.0
(All conditions	97.3	164.4	80.5	96.8	449.0 billion board feet

In the Douglas fir region there is a significant difference between Washington and Oregon in species composition. In Washington, although 70 per cent of the volume cut each year is Douglas fir, this species makes up only 37 per cent of the standing timber; the volume of Western hemlock almost equals that of Douglas fir, and the remaining volume includes significant proportions of true firs, Western red cedar, and Sitka spruce. In Oregon, 85 per cent of the volume cut each year is Douglas fir, which constitutes 78 per cent of the standing timber, with only minor amounts of hemlock and other species. Because of the large volume of hemlock and true firs in Washington, the pulp and paper industry is much more important in Washington than in Oregon.

The only process by which Douglas fir is pulped is the sulfate (or Kraft) process, and so far there are only a very small number of sulfate mills in the region. These include one at Springfield, Oregon, three on the Columbia River, and two on Puget Sound. A sulfate mill, fiberboard plant, or chipping plant (which ships to a pulp mill or board plant) greatly increases the possibility of close

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utilization of mill waste, and makes profitable the use of logs of smaller sizes and poorer quality than would otherwise be possible. Several developments along this line have given a considerable impetus to forest utilization, and thus to forest management, during the past few years.

The so-called forestry balance sheet is a comparison between growth and drain. "Drain" includes wood used, wasted, and lost to insects, disease, wind, or fire. In the Douglas fir region the 1944 growth was only 3.7 billion board feet as compared to a drain of 12.0 billion board feet. The growth goal set for the region by the U. S. Forest Service estimate is 10.0 billion board feet. This goal can be achieved in fifty years if reasonable progress is made toward improving forest management by most forest owners. The potential growth in the region under moderately intensive management would be 12.6 billion board feet, or more than the current drain. Until the decadent old-growth stands of the Douglas fir region are cut, they will annually decrease in volume. It is only when they are replaced by vigorous young stands that the region's growth can balance decay and other drain. The federal access-road program (a self-reimbursing subsidy) is intended to open up the now economically inaccessible areas and speed the utilization and salvage of the old-growth and decadent timber, and to reduce the pressure for cutting the immature stands.

The forest economy of the Douglas fir region is now in a rapid transition from "mining" timber to "tree-farming." The concept of the forest resource as static or as a store of forest wealth is giving way to the concept of the forest resource as dynamic, as a wealth of growth-capacity.

The Business of Douglas Fir Forestry. In forestry many possible practices are desirable and feasible from a biological or engineering point of view, but impractical or undesirable when an economic or financial test is applied. An example is in the silvicultural operation of pruning. An open-grown stand of rather limby 25-year-old Douglas fir timber is to be harvested at age 65. If these trees are ever to produce clear lumber, immediate pruning will be necessary. If selected crop trees are pruned for 18 feet of their length at a cost of $30 per acre, the pruning will result in an estimated increase in value, at the time of harvest, of $200 per acre (in this hypothetical case). Investing $30 and getting $200 in return would seem like a splendid investment, but the time and interest factors have been disregarded. If the money to pay for the pruning must be borrowed at 6 per cent interest, with both principal and interest to be repaid at the time of harvest, then the amount to be paid will be $30 accumulated for 40 years at 6 per cent compound interest, which will amount to $309. So the pruning is physically feasible and aesthetically desirable, but economically impossible. Or if, instead, the owner could use his own money either to finance the pruning or to put in an alternative investment to earn 5 per cent interest, his $30 per acre investment in pruning would have to return $211 in order to pay as well as the alternative investment.

This illustrates the necessity in private forestry of (1) keeping costs less than gross earnings and (2) making only those investments which give promise of returns commensurate with the amount invested. The investor or businessman putting his money into a forestry enterprise should be concerned with the amount of money he must invest or leave invested, and the rate of return on that investment. Choice between alternative plans of management must usually be based on comparing the estimated long-run financial results of each, allowing for differences in time by applying time discounts, and choosing the alternative that promises to yield the highest rate of return per dollar invested, or at least a satisfactory rate of return, together with other benefits.

Another example of the difference between financial and physical considerations is in the choice of a rotation (number of years to grow a crop of trees under sustained-yield management). At present, in the Douglas fir region most rotations, particularly on public forests, are chosen on the basis of a number of practical considerations, including condition of the timber and time required for opening up the area. Many foresters give some attention to the age to which trees should be grown to produce the greatest possible average annual volume growth; this might occur with rotations varying from 80 to 110 years, depending on site quality and basis of measurement. If a financial version of this method were used, an attempt might be made to choose the rotation that would produce the greatest growth in value per acre per year (or the greatest net annual earnings per acre); this method would result in rotations such as 150–170 years. Yet private forest owners think in terms of 60–90 years, most of them not seriously considering longer rotations. This dif-

The **Weyerhaeuser Timber Company plant, Springfield, Oregon. A sawmill, a pulp and paper mill, a plywood plant, and a Pres-to-Log plant, fully integrated, make complete utilization of Douglas fir and wood of other conifers possible. Even material from defective logs is used.** (**Photo by Valley Flying Service, Inc.**)

ference results from a desire for a good rate of return on investment, so as to maximize the total net earnings per year. With a rotation of 150–170 years, the amount of money invested in growing stock (timber) and land would be so great that only a very low rate of return on the investment could be realized. Only a forest owner who can disregard investment can afford such a rotation in a Douglas fir forest.

Many forest investments, such as immature timber or stands still economically inaccessible, are deferred-yield propositions, which are singularly unattractive to most investors, partly because they are long-term investments—although with some possibility of getting the money out by resale—but mainly because of the large, practically uninsurable risks involved. These risks include (1) physical loss or destruction by fire, insects, disease, wind, etc., and (2) market risk and risk of higher costs (higher wages or higher taxes). Any investor who assumes these risks must allow for them in the price he pays or the return he demands.

At the present time it is practically impossible to buy insurance on standing timber in the Douglas fir region at a reasonable rate. An encouraging indication is that several private insurance companies are now said to be seriously considering underwriting this type of risk.

Another difficulty in financing deferred-yield forestry enterprises is the fact that banks that are members of the Federal Reserve System are not allowed to lend money secured by forest land and standing timber because of the ruling that forest land is unimproved real estate and hence not allowable for security on loans. Practically speaking, the only long-term forest credit available is from purely personal sources. Banks will lend money on short-term loans secured by felled timber in cold decks, or secured by accounts receivable. But under no circumstances will a bank even consider a forest loan for a period longer than 10 years, which is a short term by forestry standards.

Federal legislation has been proposed by forest economists and agricultural economists to create a Forest Credit Division in the Farm Credit Administration, to make long-term loans on a business basis to forest owners, with low rates of interest and conditions of repayment tailored to fit the needs of the borrower; but such legislation has not been enacted into law.

Forest taxation in the Douglas fir region was, a few years ago, only a minor problem to forest owners; but now that federal income taxes on corporations and individuals have become almost confiscatory, and general property taxes on forest land are increasing in this region, taxation has become a major problem. Because of the economic necessity of paying only the smallest possible legal federal income tax, many companies find that they must choose their management practices on the basis of the effect on the amount of income tax payment, rather than on the basis of long-term profits, where taxes are considered on the same basis as other costs. The taxation of immature timber as real (or personal) property has a strong tendency to encourage liquidation of the timber whenever the tax levy become sizable. Many forest owners believe, therefore, that the entire basis of forest taxation might be reconsidered from the standpoint of its effect on forest conservation.

Contrary to the situation in other industries, most operators of sawmills and of logging operations do not know exactly how much money they make or lose on trees or logs of different sizes, quality, or distances from the mill; hence they have only an approximate idea of their economic margins and of the factors causing variations in their costs. This is because of the extreme variability among the different logs and trees encountered and in the logging and hauling conditions. In order to obtain an accurate knowledge of costs and margins it is necessary to make a time-and-cost study for each major variation in mill and woods conditions.

Like most businesses, forestry enterprises are strongly affected by variations in price and demand related to business cycles. This is less true of pulp companies than of lumber companies. During a general business depression lumber prices tend to be so low that very careful planning and management, even during periods of good prices, are necessary for a lumber company to ride safely through a major depression. Such planning will include (1) keeping the mill capacity small to avoid heavy carrying charges during shutdowns or periods of low activity; (2) cutting the decadent, low-quality, remote, and high-cost stands during periods of good prices; and (3) leaving some accessible stands of good-quality, low-cost timber for cutting during periods of low prices.

In looking over a clear-cut area in the Douglas fir region, one is frequently dismayed at the large amount of usable wood left on the ground; and some might even indulge in unkind thoughts about those who did the logging. These thoughts may be justified if the material left on the ground includes logs or trees of all sizes and qualities, as evidence of careless logging. But if there is evidence of the logger's having attempted to adhere to some standard

as to minimum diameter and minimum quality, perhaps there is something to be said in his behalf.

Only the most rabid wood conservationist would argue that a logger, forced by topography to use high-lead or other cable method of yarding, should take every last stick felled or knocked down, even those which would not pay their way to and through the mill. Any such logging of submarginal logs could be required only as a definite expenditure for reducing insect or fire hazard or for other silvicultural purpose.

Even if it can be shown that the logger could have earned 10 or 20 cents per thousand board feet by taking some of the logs left on the ground, the logger may have a good argument. What was he trying to conserve? Wood? Labor? Land? Capital? If he was trying to conserve labor and capital by not wasting time and money on trees or logs that could net only a few cents, when the same amount of capital and labor could have been applied so as to produce net earnings of 50 cents or $1.00 or more per thousand, he was conserving resources just as important as wood.

We tend to forget that a type of conservation that is making most complete or efficient use of one resource may be using other resources quite wastefully. It is virtually impossible to obtain the most efficient use of each of several resources simultaneously. Proper conservation policy would be to use efficiently those resources that are most scarce or most expensive. The other resources should then be used with care, but are bound to be used at less than their own maximum efficiency.

What about the economic future of Douglas fir and the Douglas fir region? Predictions are dangerous and should be qualified. Three things, however, can be said with assurance: (1) Present trends toward closer utilization of Douglas fir are encouraging and are likely to continue. Even Douglas fir bark will become a valuable chemical raw material, yielding wax, tannin, and other extractives. (2) The progress made in the management of Douglas fir forests during the past decade has been amazing; further improvement may be expected. (3) The population of the Pacific states is likely to continue to increase for several decades, thus increasing the local demand for forest products.

Two fields in forestry in the Douglas fir region need further study and development: (1) the financial and management problems of the small private forest; and (2) the economics of public forestry and forest administration, including the further application of the analysis of costs and benefits and of time discounts to contemplated public projects, and the removal by Congress of legal and financial obstacles to the efficient business administration of local units of federal forestry agencies.

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BOOK REVIEWS

ELEMENTIST GOING UP

The Sensory Order: An Inquiry into the Foundations of Theoretical Psychology. F. A. Hayek. With an introduction by Heinrich Klüver. Chicago: University of Chicago Press, 1952. xxiii + 209 pp. $5.00.

IF YOU are going to write a theoretical psychology, you can start at the top with psychological events as they occur in vivo and work down to some elements (like sensation, nerve impulses, reflexes) at the bottom, or you can start at the bottom and work up. In either case you count as an elementist. If you are convinced that analysis of that sort distorts nature, you can go over to field theory or some sort of wholism, and still you can go *von oben nach unten* or the other way. Hayek is an elementist going up, so three fourths of the other theorists will dissent from his propositions unless the cogency of his argument makes converts of them. The human mind is, however, scarcely so rational as to make that miracle probable. If Hayek wrote to gain disciples, he had better have written more persuasively and less precisely, for one can get bored by the deadly logical progression of this book long before he can find a cogent phrase to which he dares register vigorous dissent.

Hayek is talking science—that is to say, he is dealing solely with generalized objects, not the stone that Dr. Johnson kicked but the constructs that make up knowledge. So he has (1) the world of stimuli, where you meet events like radiation with a given wavelength, not such stimulus objects as you buy from a catalog and put in an apparatus case. And then he has (2) the neural world of nerve impulses, and they too, mind you, are constructs, generalized events inferred from observation of electrical potentials. (Hayek dodges the problem of operational definition by taking a firm stand *ab initio* among the hypothesized constructs.) The third world (3) is psychological or mental, where the elements are sensations. Literally, sensations are constructs, too, not at all bits of actual or private experience. Nor has Hayek any use for phenomenology or positivism in science, although the sort of positivism he is eschewing is more the experiential Ernst-Mach kind than what the Vienna Circle made Mach's views over into.

The psychological events are constituted by a large class of hierarchical neural relationships, only a small portion of which are conscious. The rest of them are unconscious, preconscious, or potentially conscious. That is all right, for it is exactly what ought to follow from the conception of mental events as constructs and the author's further belief that the stimuli, the neural impulses, and the sensations are not in different worlds but fundamentally all of the same kind of "stuff." Is Hayek a physicalist? He'd not like to be called one, for then he might be thought a behaviorist (much too narrow for him are those exponents of an empty organism) or a positivist.

As you work from below up, you must resort to some principles of association to synthesize the elements into larger and larger wholes. Hayek's word for synthesis is *classification*. And his principle of classification (association) is frequency of temporal contiguity, that patient wheel horse of the psychological band wagon since Hume and, in a way, since Aristotle. Right there lies my first major dissent. Hayek ought not to rest his whole structure on this disputed principle. It is true, of course, that frequent occurrence of association tends to be followed by recurrence of the associated terms, but Hayek is not talking at this naïve level. He and we need to know what is the physical nature of connection. For the moment, Hayek sounds like an operationist. All he has said is that frequent concurrences tend to recur; yet we know that they do not always recur, and also that frequency is not a necessary condition for recurrence. Moreover, as Hayek himself says elsewhere, these events need to be fitted into space as well as into time; so when the connections are made, whether it is by frequent concurrence or otherwise, you still need to think of them as somewhere. (Hayek is not thinking of any such controversial connectors as synapses; he is dealing with an ideal nervous system, one like Avenarius' System C, an als-ob nervous system.) You see, the number of combinations of a thousand things taken any number at a time is 2^{1000}, which is ever so much greater than the total number of electrons in the universe (10^{300} *vs.* 10^{79}), and, although Hayek would, of course, not expect every combination to form a class in the sense that it had a unitary effect, still the problem of getting a common effect for so many groups of fibers, whose only community is temporal and not spatial contiguity, is great. Where would all the connections be?

The concept of the formation of classes (larger and larger wholes) is Hayek's way of dealing with generalization, and thus with equivalence of stimuli and with subsequent psychological events like abstraction and transfer. He might have modernized his speech and have talked about transmission of information, and then generalization would have become positive entropy, and the reinforcement of potential sensations negative entropy. But to everyone his semantic taste. Hayek's psychological system is one of smaller classes being grouped into larger, with all the possible cases of overlap independently functional. Thus you start with sensory elements and you get on by classification to larger and larger sensory structures by means of classification and both further classification and reclassification.

Every psychological system needs a dynamic principle in addition to the associative one—set, determining tendency, need, attitude, drive. This principle is superordinate to the basic associations and seems not often to

be thought of as depending on past frequency for its strength. Hayek recognizes this essential, but he reaches his goal by more classification—one class of sensory phenomena reinforces another that has been but potential so far as its having any effect goes, thus making it effective by reinforcement. This is the way set was often supposed to work before Ach (1905), and perhaps we may come back to it. Hayek does not convince me, though. His logic gets thinner the further it elevates us in the system.

Eventually Hayek deals with such concepts as consciousness, attention, and conceptual thought, but here he seems to me naive. You do not need consciousness at all in a system of this sort. Why lug it in? Just to prove that the system leaves nothing out? Well, then set up some criteria for consciousness, and let them reflect a knowledge of the discussion of these criteria that has gone on for so many years. One would think from reading this chapter that Hayek believes that private experience belongs in science. You have to keep nudging yourself and saying: "Remember, consciousness is physical, a physical relationship."

And that point troubles me all through this discussion. Hayek talks like a mind-body dualist and yet presently insists that he is not. Such a seeming contradiction is logically possible, if you know the transformation formulas from sensory quale to neural relationship, but it is misleading to persons who have been brought up to believe that they can know about private consciousness that has never been published. They think they have private, absolute awareness of the sort of stuff that Hayek is considering. But he is not being phenomenological. He is considering neural relationships which are wholes because they have single common effects that in combination have their own joint later common effects, and so on. All this makes sense, but it is not common sense.

The book is remarkably tight. It is full of careful logical sense. It gets harder as you pass from the simple to the complex, partly because you are farther from your base, and partly because of this interference between logical consequence and common-sense phenomenology. Hayek is a Viennese economist, long resident in London, and a British citizen, now at Chicago, where he has found stimulus and understanding in Heinrich Klüver. Half the time I read with amazement at the extent of his reading and comprehension in a field that is not his *Fach*. The other half I tear my hair at his lack of historical orientation in psychology. Even when he is right (and that, I should say, is most of the time), you wish he would do a reasonable share of the work in connecting up his thought with that of his predecessors. Physical theories of mind and consciousness, and relational theories, are not new, and one would like to be shown, not merely the content of Hayek's mind, but his theory in the perspective of the history of scientific thought about these matters. Nevertheless, let me add, to my reminder that Hayek's views have antecedents, that I feel sure that no one has done this particular kind of a job nearly so well. It is a physicalistic system of psychology, mind, and (if the word must be used) consciousness. It is not absolutist in any sense; the facts in it are relations and the system is not closed except, for convenience, by the skin of the organism. It is elementistic and it makes sensations, which are physical constructs and not phenomenal bits of consciousness, basic to the structures which it builds. Thus it can be physicalistic and not primarily behavioristic. I do not for a moment believe it is the last word on this matter, but it is one word, and the best word I have ever heard spoken from this platform.

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HOMOLOGY AND COHOMOLOGY

Foundations of Algebraic Topology. Samuel Eilenberg and Norman Steenrod. Princeton, N. J.: Princeton University Press, 1952. xv + 328 pp. $7.50.

The greater part of the algebraic topology is concerned with the concepts of homology and cohomology, which owe their popularity to Poincaré's attempts to classify manifolds in terms of a calculable set of invariants. Certain groups, called homology and cohomology groups, are associated with topological spaces, and homeomorphic spaces have isomorphic groups. Thus they provide a set of invariants, which in certain cases can be calculated; but they are insufficient, except in the case of compact two-dimensional manifolds, to solve Poincaré's problem, for isomorphism of the groups does not necessarily imply homeomorphism of the corresponding spaces. This indicates that some part of the original structure which defines the topology has been lost in the transition to the groups. Despite this, a study of homology and cohomology reveals much beautiful and interesting mathematics, and there are many applications. One important feature is that topological problems are transformed into algebraic ones, which are usually easier to solve.

In this book the authors have attempted to place homology and cohomology on a firm basis by means of an axiomatic treatment. This differs from previous axiomatizations of parts of homology theory in that the transition from spaces to homology groups is subjected to axioms, which has never before been attempted. Full accounts of the more familiar homology theories are given, and they are discussed in the light of the axioms. A second volume on further aspects of the subject is in preparation.

Chapter I begins with certain topological and algebraic preliminaries, but some knowledge of the basic concepts of topology and group theory is assumed. The axioms for homology are then stated, followed by the dual axioms for cohomology. Various general theorems are proved, in particular the invariance theorem, and the chapter ends with theorems on the homology of Euclidean spaces. Chapters II and III are concerned with simplicial complexes, which belong to the oldest and probably most familiar part of algebraic topology. The necessary definitions and geometric details are

given in Chapter II, and in Chapter III homology on simplicial complexes is discussed. The main result is that two homology theories, with isomorphic coefficient groups, on the category of triangulable pairs, are themselves isomorphic. The ideas of "category" and "functor" are explained in Chapter IV. These place certain concepts on a formal basis, and avoid a considerable amount of repetition in the subsequent chapters. The ideas appear to have been of importance in the development of the book. Chain complexes are discussed in Chapter V, and in Chapter VI the classical homology theory of simplicial complexes is presented. Chapter VII is devoted to singular homology theory, and it is here that the existence of nontrivial homology theories is first established. Systems of groups and their limits are discussed in Chapter VIII, which leads up to the Cech homology theory in Chapters IX and X. In the final chapter, some applications are given, notably the Brouwer fixed point theorem and the fundamental theorem of algebra. Most of the chapters are concluded with notes and exercises, the former being partly on historical aspects and partly on the subject matter.

The book will, of course, appeal more to topologists and algebraists than to anyone else. The newcomer to algebraic topology will probably be confused at first. The axioms, coming near the beginning of the book, without previous explanation, place a burden on the uninformed reader, who has to accept them without knowing how they came about. This, of course, is unavoidable without a considerable amount of trouble, and only a slight knowledge of algebraic topology is necessary for an appreciation of the axioms.

The presentation throughout is clear and precise; definitions are always given where they are necessary, and no doubt should be left in the reader's mind as to what is being proved and how it is being done. One significant feature of the book is the extensive use of diagrams to illustrate various definitions and the proofs of certain theorems. These diagrams, which consist of networks in which the vertices represent groups and the edges represent homomorphisms, are extremely useful, and assist greatly in the understanding of the situation.

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WOOD PHYSICS

Textbook of Wood Technology. Vol. II, *The Physical, Mechanical and Chemical Properties of the Commercial Woods of the United States*. H. P. Brown, A. J. Panshin, and C. C. Forsaith. New York: McGraw-Hill, 1952. 783 pp. $10.00.

THIS is the second volume of the *Textbook of Wood Technology* to appear under the joint authorship of Brown, Panshin, and Forsaith. Although the responsibility for this volume is shared by all three authors, it is principally Forsaith's contribution to the textbook, and represents a greatly expanded and revised version of his *Technology of New York State Timbers* (1926), just as Volume I was a revision of Brown and Panshin's *Commercial Timbers of the United States* (1940), which was in turn a much-enlarged and modified version of their *Identification of the Commercial Timbers of the United States* (1934).

The two-volume set, according to the authors' preface in Volume I, was designed to cover the whole field of wood technology, so that a student could find all factual information within one text. And the publisher's statement on the jacket, "Here is the second volume of this outstanding two-volume work, which now stands as the only comprehensive text in English embracing all phases of wood technology," suggests that this design in fact has been accomplished. In order to report the objectives fairly, however, it must be noted that the preface to Volume I indicates that the chemistry of wood is to be dealt with only "in so far as its chemistry should be known to forestry students and to wood utilists other than chemists," and the preface to Volume II points out that it includes "an abridged survey of this very extensive subject."

Volume II deals with the physical and chemical properties of wood, in three sections: "The Physical Properties of Wood," "The Mechanical Properties of Wood," and "The Chemical Properties of Wood." Part I is concerned with the nonmechanical physical properties of wood and embraces such subjects as density and specific gravity, relationships of moisture (including shrinkage), relation to heat, sound, light, and electricity, and, surprisingly, wood bonding and finishing.

Part II considers the mechanical physical properties and, on a bulk basis, overshadows the other two parts, since it comprises almost two thirds of the book. It includes such subjects as the mechanics of short wood columns and wooden beams, standard wood-testing procedure, working stresses, variation in strength properties, strength of laminated beams and plywood, holding power of fasteners, and stresses in framed structures. It is pertinent to note that about a third of this section is devoted to fundamental concepts and applications of mechanics and strength of materials, which this reviewer believes are more explicitly dealt with in treatises on these specific subjects.

Part III, as already pointed out, is an abridged and elementary approach to the subject, expressly designed for the "layman approaching the subject for the first time," and encompasses only 40 pages. It is divided into three chapters: The Chemical Components of Wood, Effect of Chemical Treatments on Wood, and Thermal Reactions of Wood and its Decomposition by Biological Agents.

From the standpoint of teaching wood physics, the order of presentation of the broad subdivisions is quite satisfactory, and the frequent use of illustrative problems greatly facilitates the understanding and application of the principles and techniques that are presented. After using the volume in the classroom for one semester, however, it is this reviewer's opinion that considerably more painstaking editing and revising of

many parts of the manuscript and proof were needed before publication. There are numerous typographical and some textual errors, inconsistencies, and omissions that confuse the student and cause him to lose confidence in the text. And entirely aside from these errors, of which we found more than 40, many portions of the text lack the clarity and conciseness of expression that one would hope to find in a technical presentation of this nature.

In the preface to this volume, it is pointed out that no pretense is made of presenting an exhaustive study of the differences in physical reactions that characterize the different woods of the United States. It would seem, however, that inclusion of a few tables of basic data, such as the strength values of clear wood, shrinkage, and structural grades, with working stresses of the more important commercial species, would have come closer to realizing the goal stated in the preface to Volume I. Also it is unfortunate that some of the illustrations in Volume I, such as those pertaining to the fibrillar structure of cell walls, kiln-drying defects, and compression wood, are not duplicated in appropriate places in Volume II, for they are needed to supplement some rather involved word pictures. Finally, it would seem that more of the important references, and more references of recent date, should have been listed for most of the subjects covered. In this respect Chapter V, on Wood in Relation to Sound, Light and Electricity, is a welcome exception.

Although the book is definitely a contribution to the literature of wood technology, this reviewer regards it as not up to the standard of Volume I, and he hopes that an early revision will bring it more in line with that well-received work.

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MYTHS AND RELIGION

Djanggawul, An Aboriginal Religious Cult of North-Eastern Arnhem Land. Ronald M. Berndt. New York: Philosophical Library, 1952. (Printed in Great Britain.) xxiii + 320 pp. Illus. $7.50.

THE author of *Djanggawul* is a lineal, if at times critical, adherent of the "functional" symbolic approach to mythology and ritual taken by Durkheim, Radcliffe-Brown, and Warner. In fact, he and the last-named have worked in the same area and dealt in much the same way with certain myths of the natives of Arnhem Land in Australia. Comparisons with the present work and *A Black Civilization* (1937) are therefore inevitable but must here be omitted.

Berndt deliberately minimizes theoretical formulations, especially the psychoanalytic, and stresses the raw material, with only enough interpretation and analysis to make it intelligible. This puts a severe strain on the nonspecialist, for he is provided with almost no ethnographic background and is assaulted with distracting native terminologies, dreary and repetitious song texts, and multiple-guised persons and objects. It is consequently doubtful, as the author wishfully believes, that the beauty and profoundness of the Djanggawul cult will influence administrators, missionaries, and teachers, and cause them to adopt a more tolerant attitude toward aboriginal life.

Nevertheless, for the professional anthropologist the book has solid merit and exciting data. Using the translated texts of 188 songs as a basis, it describes the Djanggawul cult. The Djanggawul are three ancestral beings—two sisters and a brother—who lived in the mythical past, and the narrative that depicts their actions also serves to substantiate and sanction the rituals which accompany them. The three ancestors institute religious ritual, dogma, and behavior. They are associated with the sun, which, with its warmth, causes people and animals to grow. They are, too, creative ancestors and therefore held in great reverence. Certain sacred symbols carried along with them in their travels have procreative significance and are identified with them. The myth shows the sensitive awareness of the aborigines that sex is vital for the survival of all life. Thus, the Djanggawul bring rain, germinate the soil, and ensure the natural resources of the land.

Djanggawul, then, is drenched in sex, without, as Berndt points out, being erotic. It is a good argument for illustrating the heights which can be reached by an "old Stone Age" people.

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ADVANCES IN MEDICINE

Recent Progress in Hormone Research. Proceedings of the Laurentian Hormone Conference, Volume VII. Gregory Pincus, Ed. New York: Academic Press, 1952. 527 pp. $9.50.

THIS book is a stimulating, if somewhat overwhelming, tribute to the almost frightening strides with which the science of endocrinology hurries forward. Certainly no one who, for pedagogical or clinical reasons or simply as a matter of intellectual curiosity, feels compelled to keep abreast of this rising flood of information, and who possesses the necessary background information, can afford to miss this volume. All such readers will feel a debt of gratitude toward its contributors.

A record of the Proceedings of the 1952 Laurentian Hormone Conference, the book is divided into four sections entitled, respectively: "The Pituitary Hormones," "Sex Cycles," "Aspects of Steroid Hormone Chemistry and Physiology," and "Hormones and Metabolism." Each section contains four or five papers, all of them interesting and timely. As is usual nowadays, emphasis falls heavily on the steroid and pituitary hormones.

This reviewer, admittedly guided by his own limitations and interests, was particularly impressed with Long's masterly summary of his views concerning the

regulation of ACTH secretion, Markee and his associates' account of their researches on the nervous control of gonadotrophin release, and Folley's studies on the physiology of lactation. The discussion of the physiology of the human menstrual cycle by Smith and Smith was somewhat disappointing, for their highly significant work deserves to be brought into sharper focus than was done here.

Gassner's report on the physiology of the gonadal cycle in domestic animals was one of the most thought-provoking. Certainly some of the most exciting work on the physiology of reproduction today is being done in the field of animal husbandry, work which is not, on the whole, too well reported in the medical literature. As medical science prolongs the life span, agricultural and veterinary science must provide an ever-mounting supply of food. Intimate knowledge of the mechanics of reproduction not only aids the obstetrician and the gynecologist, but it also insures more butter, eggs, and meat to support mankind's growing appetite. Anything that keeps the medical and veterinary scientists in step with one another will postpone the day, considered inevitable by many, when the world's population outstrips its food supply.

Other equally important papers in this volume deal with the chemistry and synthesis of steroid and pituitary hormones; hormonal regulation of fat and carbohydrate metabolism, as well as water and electrolyte balance; the relation between hormones and antibody production; hormones and hypersensitivities; and the histological changes produced in the adrenal gland by inanition.

The book is well organized, printed, and edited—a thoroughly acceptable companion to its predecessors. No other conference seems to encompass quite so much endocrinology as does this one. No doubt this is due to the peculiar genius of Gregory Pincus, who has edited this as well as other volumes in the series. Omissions are inevitable in any single year and of no consequence if rectified later. Certainly one of the conferences in the not too distant future should devote some time to the growth hormone, the thyroid hormone, and possibly even the parathyroid hormone. Perhaps it might not be out of place to include as well something on the growing body of information about the action of hormones in the invertebrates, especially in the insects and the crustaceans.

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NAIVE HYPOTHESIS?

The Lost Discovery: Uncovering the Track of the Vikings in America. Frederick J. Pohl. New York: Norton, 1952. 346 pp. Illus. $3.75.

IN *The Lost Discovery* Frederick J. Pohl sets forth his opinion that Bjarni, lost on a voyage from Iceland toward Greenland in A.D. 986, saw Cape Cod, Massachusetts, Nova Scotia, and Newfoundland before finally arriving at his destination. He also believes that Lief Ericson, a few years later, made his way around Monomoy on Cape Cod to enter and build a camp upon the ponds at the head of Bass River in southeastern Massachusetts. Thorvald Karlsefni, Lief's brother, followed him to Vinland and eventually was killed, according to Mr. Pohl, in an encounter with the Indians at the mouth of Somes Sound, Mount Desert Island, Maine. Thorvald is said to be buried in a field there; his remains are yet to be found. The tale continues, and practically every place, no matter how briefly or incompletely described in the sagas, is rather precisely identified. Pohl even goes so far as to interpret the extremely controversial Zeno narrative to mean that the harbor called Trin is Guysboro Harbor in eastern Nova Scotia. He figures that this harbor was entered by the expedition on Trinity Sunday, June 2, 1398! These notes comprise only a selected and perhaps unsatisfactory listing of a few of the amazing results of the author's ingenious and indefatigible work during the past few years. The significance and validity of the results are another matter.

There is no term like "science fiction" to describe books like this, dealing as they do with a combination of geography and history. Like Holand, Goodwin, Horsford, and a host of others, Pohl has let his vigorous and untrained imagination go unchecked as he reads and dissects the translations of the sagas. The results appear in a well-organized book, the style of which is much better than usual in this type of literature. He has constructed an amusing and highly readable yarn about the comings and goings of the Norse. There are minor inconsistencies in this, as is to be expected, and at times the so-called logical word-by-word interpretation is incredible if not ridiculous, but after all a reader must not be too particular under such circumstances.

A scholar seriously concerned with locating places where the Norse landed in America, and in the history of the encampments and voyages, will find nothing new in the book except a lot of ideas that have little or no basis in fact. Mr. Pohl has put forward a naïve hypothesis. The interpretations of the translated texts of the sagas are based upon rather detailed and specific statements concerning navigation and conditions at sea and along the New England coast. It is quite obvious that the author is either unfamiliar with the whole subject or that he has not understood the wealth of accurate nautical information available.

To support his contention that the Norse landed at various spots along the coast, the author refers to the numerous artifacts and other features commonly mentioned in the "Norse literature." All these things are matters of extreme controversy, and many of them have been completely repudiated by experts who are more fully informed than is Mr. Pohl. The author produces little or no information which abates the controversies. In fact, in some cases he does not even admit that variant and important opinions concerning the validity of the evidence exist. In other instances, particularly regarding archaeological evidence, Mr. Pohl naïvely dis-

misses the careful recent work of experts in a manner that reveals both his uncontrolled bias and his ignorance of the fundamental concepts upon which the work was based. In summary, this is a pleasant book that can keep a reader entranced with the workings of a man's imagination. One is gratified to read Mr. Pohl's easy solutions to the many problems that have frustrated scholars for practically a century. However, this book adds no new facts or sound opinion to what was previously known about the Norse in North America.

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FIELDIANA

Mogollon Cultural Continuity and Change: The Stratigraphic Analysis of Tularosa and Cordova Caves. Fieldiana: *Anthropology*, Vol. 40. Paul S. Martin, John B. Rinaldo, Elaine Bluhm, Hugh C. Cutler, Roger Grange, Jr. Chicago: Chicago Natural History Museum, 1952. 528 pp. Illus. Paperbound, $8.00.

THE name Mogollon, derived from a nearby mountain range, is used to designate a series of archaeological assemblages occurring in the San Francisco River drainage in west central New Mexico and adjacent portions of Arizona. Long-term archaeological investigations were started there in 1939 by the Field (now Chicago) Museum of Natural History. The work of earlier seasons, previously reported upon, was restricted to sites in the open, and although a useful body of data pertaining to Mogollon remains was accumulated there was still need for stratigraphic evidence to substantiate the sequences developed from typology and to obtain a collection of objects made from perishable materials which would be representative of that part of the material culture. Formerly occupied caves are ideal for such purposes, and, although formations of that nature are scarce in the area, two were found that answered the requirements. Both are in the Apache National Forest, Catron County, New Mexico. Tularosa Cave, located about a mile east of the town of Aragon, was excavated in the summer of 1950. The other, Cordova, is about six miles south of Reserve and was dug during the 1951 field season. Tularosa Cave yielded 2130 well-preserved specimens and large quantities of plant remains. Cordova Cave was not as productive; only 1200 artifacts and considerably less plant materials were recovered, because an extensive conflagration had destroyed large areas of the deposits during the period of aboriginal occupation.

The major portion of the publication is devoted to detailed descriptions of the artifacts from the caves and discussions of their significance and relationships. Information about the various items is combined with that obtained from the open sites during previous years, and all the traits of the tangible Mogollon culture are listed. In their study of the data the authors arrived at the conclusion that there were three major changes in the growth of the cultural pattern, each coinciding with the beginning of what they call a "Phase." The causes for the changes are not completely known, but it seems certain they were in no small degree the result of influences derived from Mexican cultures in the south, the Hohokam culture in southern Arizona on the west, and the Anasazi in the plateau area to the north. Throughout, however, certain basic traits appear to have persisted and to have provided a definite continuity. Certain changes in plant and animal remains seem to correlate with those in the culture, and marked modification of the subsistence pattern may have had a direct bearing on them.

Carbon 14 tests on corn from the lowest levels of Tularosa Cave gave dates of 2300 ± 200 and 2223 ± 200 years before the present, and the authors estimate that it was abandoned between A. D. 1000 and 1200. They think the cave was more or less continuously occupied for about 1500 ± 500 years. The major changes in the culture are believed to have occurred at about 150 B. C., A. D. 700, and A. D. 1000.

In the opening section, which discusses the organization of the report, it is stated that the authors have tried to put it together so "as to make it easily usable by specialists, students, and general readers, and to make it readable." It may be said that on the whole they have succeeded, but general readers, as well as some students and specialists, may find it difficult to grasp their concept of the meaning of a Phase and the arbitrary assignment of chronological positions or phases to levels on the basis of the percentage of pottery types present. The numerous illustrations will be very helpful to those making comparative studies. The publication certainly is a contribution to the knowledge of Southwestern archaeology.

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THE RECORD OF THE ROCKS

The Origin of Metamorphic and Metasomatic Rocks. Hans Ramberg. Chicago: University of Chicago Press, 1952. xvii + 317 pp. Illus. $10.00.

THE subtitle, "A Treatise on Recrystallization and Replacement in the Earth's Crust," better expresses the coverage of this important book. It deals with the thermodynamics of metamorphic processes (39 pp.) and gives equilibrium diagrams (54 pp.) of metamorphic minerals. In the section on the chemical kinetics of metamorphism, Dr. Ramberg does not regard the natural moisture in rocks as the medium for mineral solution, transfer, and subsequent deposition. He likens the "pore fluid" to the artificial ether for the propagation of light. He prefers "the reactive ions, atoms, and molecules in the rocks." The author emphasizes granitization, not magmatism.

Ramberg discusses the belief of some structural geologists that the lineation of spindle-shaped minerals is perpendicular to the direction of plastic flow, whereas others think it coincides. An experimental solution of

this is difficult because it is a very slow process. The results of the deformation of metals have been used as a clue to what may happen in rocks. The yield point of metals is not constant under a given P–T condition but depends on the duration of the test. The author leaves the structural properties of deformed rocks to others, as it is too large a subject for a book of this size. He shows briefly how the old and new minerals reorient themselves under the influence of stress.

The author is of the opinion that quartz-feldspar rocks are more readily deformed than the basic types. In dry melts the relationship is reversed. He believes the higher concentration of —O—Si—O— bonds in acidic rocks is the cause of the difference. It is possible that ultrabasic rocks are injected as solid aggregates.

Thirty-three pages are devoted to mineral facies in metamorphic rocks, following the work of Goldschmidt and Eskola. Ramberg presents 17 triangular (ACF) diagrams and 40 equations. The latter are so simplified that the polycomponental nature of many minerals is not evident.

The most interesting, and at the same time the most controversial, section of the book is the "transfer of matter through rocks." Ramberg thinks that the rocks, regarded by some as "soaked" by magmatic matter with a low viscosity, are in reality affected by the "agency of metamorphism," penetrating crystalline aggregates and passing through interconnecting capillary pores; or that the rocks behave "like a semipermeable 'membrane,' permeable to individual atoms, ions, or molecules but behaving like an insulator against the bodily flowing pore fluids" (p. 174). In this manner potash, soda, and silica penetrate rocks and change hornblende into biotite and epidote, muscovite into potash feldspar, and so on.

Two very short chapters, one on "contact metamorphism" and the other on the "metasomatism in sedimentary rocks," leave much to be desired. The only reference in the latter is to Pettijohn. The author lists dolomitization and silica-replacement. His last major section is devoted to the metamorphism in regionally metamorphosed complexes. Here he is on familiar ground: the plastic deformation, recrystallization, and replacement within pre-Cambrian shield areas. This leads to the questioning of the actual existence of quartz-feldspar plutons with high viscosity and to the supposition that they were "developed in the solid state by activation, diffusion, and consolidation of ions, atoms, or molecules."

Dr. Ramberg's contribution would be perhaps more attractive if a better balance could have been attained between the processes of the crystallization of magmatic melts ("crucible" petrology), on the one hand, and metasomatism by liquid and gaseous material attacking the consolidated products, on the other. The word "deuteric" does not appear in the index.

A discussion of the chemical bonds in crystals composes the appendix.

The book is not always easy reading, as the author uses some technical terms in special ways; the scapolite end member, meionite, is spelled "mejonite." Ramberg uses the term "mixed crystals" for solid solutions and regards perthite as the result of "unmixing" rather than of exsolution. The book is well printed and bound, and it should be in the library of all geologists concerned with rocks.

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BRIEFLY REVIEWED

Mathematical Models. H. Martyn Cundy and A. P. Rollett. New York: Oxford University Press, 1952. 240 pp. Illus. $5.50.

THE opening sentences of this book are: "Mathematics is often regarded as the bread and butter of science. If the butter is omitted the result is indigestion, loss of appetite, or both. The purpose of this book is to suggest some ways to butter the bread." The authors certainly did not ration their butter and the result is a fascinating book giving models to illustrate mathematics.

Although the book is mainly written to encourage secondary school teachers to interest their pupils in mathematics by letting them make collections of models, it certainly can be recommended to a much wider public. The authors describe in detail the models that are part of the Sherborne collection and how they can be reproduced.

One chapter deals with models in plane geometry; another one with polyhedra, including illustrations of all the polyhedra discussed. In Chapter 4, which also deals with models in solid geometry, such fascinating subjects as torus, showing a seven-colored map, a Moebius surface, and a Klein bottle are discussed.

The last chapter deals with, strictly speaking, physical rather than mathematical models, such as the Galton Quincunx (to demonstrate binomial distributions) and machines for solving equations, such as the hydrostatic equation-solver and Mellock's electrical machine.

Altogether, this is a book which anyone who has an aesthetic sense, whether he is mathematically inclined or not, will greatly enjoy, and which should be a compulsory text for mathematics masters of secondary schools.

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Advances in Geophysics, Vol. I. H. E. Landsberg, Ed. New York: Academic Press, 1952. xi + 362 pp. Illus. $7.80.

THIS volume inaugurates a new series, edited by Dr. Landsberg with the aid of a distinguished advisory committee, and intended to present critical

reviews, summaries, and progress reports for the various branches of geophysics. The potential usefulness of such an undertaking is beyond question, and the eight papers of the initial volume establish, on the whole, a high standard. Discussions of problems of the atmosphere and upper atmosphere account for nearly two thirds of the space; in addition, there are papers on "Some New Statistical Techniques in Geophysics," "Estuarine Hydrography," "The Earth's Gravitational Field and its Exploitation," and "Aeromagnetic Surveying." Treatment of other aspects of geophysics is promised for subsequent volumes.

Some of the writers have failed to keep in mind the possibility that their subjects may interest nonspecialists, and consequently have neglected to include sufficiently comprehensive introductions; a few of the papers would have benefited from more careful editorial scrutiny and better proofreading. But these are minor defects in a generally well-conceived, well-edited, and well-printed volume.

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Understanding Heredity: An Introduction to Genetics. Richard B. Goldschmidt. New York: Wiley; London: Chapman & Hall, 1952. x + 228 pp. Illus. $3.75.

JUST twenty years ago Richard Goldschmidt placed in my hands the gift of a copy of his little book *Die Lehre von der Vererbung.* It took only a few pages of reading to discern that here was a book about heredity written with such unexampled clarity and penetrating exposition and with such simplicity and directness of style that the young student found it quite as helpful a guide to the German language as the novice to the study of heredity. The only book to be compared with it in these respects was Karl von Frisch's entrancing survey of general biology, *Du und das Leben.* The wonder arose then and persisted for many years that no one had been found to do the like in English, or even to translate these two masterpieces. Now at last we possess one of them in our own language, translated under the title *Understanding Heredity,* and preserving all the admirable qualities of the original by having been rendered into English by its own author, who for many years has been one of the leaders of genetic research and teaching in this country, since the rising tide of conflict between politics and genetics drove him from his homeland.

To bring the account of modern genetics up to date, a final chapter has been added, in addition to minor alterations throughout. This last chapter, which is entitled A Glimpse of More Technical Facts and Problems of Genetics, deals briefly with such topics as the experimental production of mutations, chromosome rearrangements, giant chromosomes, cytogenetics, the genetics of lower organisms, the role of the cytoplasm in heredity, sex determination, the action of the genes, biochemical genetics, and the relation of genetics to evolution. In these discussions the same admirably clear exposition that characterizes the rest of the book has been maintained. The aim of the author has been to whet the reader's interest and to arouse eagerness for a greater knowledge of the subject, and not to provide an encyclopedic account.

Those who know Professor Goldschmidt's eminence in the field of physiological genetics, and his "racial" views of the constitution of the genetic material and the nature of the mutational changes that participate in evolutionary processes, will be surprised to see that these radical ideas are scarcely alluded to, and Goldschmidt's own realms of genetic investigation are by no means overemphasized. To Goldschmidt the first facts and principles to which the learner in this field needs an introduction are the facts and principles of "classical" genetics. These have never been set forth better.

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The Johns Hopkins University

The Literature on Streptomycin. Rev. ed. Selman A. Waksman. New Brunswick, N. J.: Rutgers University Press, 1952. 553 pp. $5.00.

SINCE the appearance in January 1944 of the first paper announcing the isolation of streptomycin, almost 1200 publications dealing with this antibiotic had appeared in the nearly four years up to the publication of the first edition of this bibliography in late 1948. By early 1952, when the present edition appeared, over 5500 papers were listed. This calculates to a rate of publication of over two papers per day.

For the future, annual supplements rather than new editions are planned, along with digests dealing with various uses of streptomycin, such as clinical uses other than the treatment of tuberculosis.

The present volume contains 43 general references dealing with actinomycetes, antagonistic properties, and streptothricin. These are followed by 5550 references on streptomycin listed roughly in the chronological order of appearance of the papers. An author index of 67 pages includes every author mentioned in the bibliography. Forty-four pages of subject index include only the major theme of each publication.

The subject index is especially useful in providing a survey of the work done with streptomycin in particular diseases. For example, there are 89 references to its use in tuberculous meningitis, 61 in hemophilus influenzae meningitis, and 21 in gonorrhea.

This compilation is an invaluable contribution to workers in the entire antibiotic field, as well as to those specializing in streptomycin and its derivatives, since it covers all the byways as well as the highroads involved in mapping the usefulness and limitations of an antibiotic.

GUSTAV E. CWALINA
School of Pharmacy, Purdue University

LETTERS

IS HEALTH MAN'S BASIC VALUE?

Articles in The Scientific Monthly about social science usually please me, but Mr. Kattsoff's essay (**76,** 24 [1953]) raises some serious questions. On the third reading, I checked the statements that to me seem incorrect, straw-manish, or subject to debate—twenty-six in the eighteen paragraphs.

Among the straw men attacked are the "mob mind," "social forces" (as metaphysical entities), and organism theories. For fifty years or more, social scientists have been attacking oversimplification and single-factor explanations. Yet Mr. Kattsoff tells us that all values should be evaluated—and subordinated—to the single factor health; but his own discussion on page 25 tends to refute his thesis.

His term "intersubjective" suggests that he is unfamiliar with what sociologists and social psychologists were writing fifty years ago. The reciprocal interaction of persons and social structures is one of the oldest and most basic concepts of anthropology, social psychology, and sociology. Only a few social scientists have ever implied that a person can *interact* with anything except other persons. We *react* to physical and biological stimuli and *interact* (or "transact," as Dewey says) with persons.

Kattsoff evidently has not understood the work of Stuart Dodd, who makes values (desiderata) a central concept. Mr. Kattsoff also seems to misapprehend the function of statistics in scientific procedures. He appears to reify values and to believe that some values are antecedent to social conditioning and are unaffected by it. This is a curious position unless he means by values (never clearly defined) *all* factors that cause social behavior. Most social scientists probably would hold that social behavior often "causes" (is antecedent to) values, and that in all cases the two factors are reciprocal. He says (speaking of Dodd), "But his variables themselves often involve variables." Are there any variables that do not involve other variables?

How would fifty leading social scientists answer the following questions?

1. Does the article properly reflect present theory and method in your field?
2. Does it contain constructive criticism of theory or method in your field?
3. Does it attack straw men?
4. Is the discussion semantically rigorous?
5. Does it properly appraise the use of statistics in social science?
6. What are its ontological and epistemological implications?

Read Bain

Department of Sociology
Miami University

THE HUMAN FACTOR IN MACHINE DESIGN

As the leading manufacturer of aircraft instruments for the past quarter of a century, we read with interest the article by Leonard C. Mead and Joseph W. Wulfeck entitled "Human Engineering."

Although otherwise excellent in detailing the place of human engineering in aviation safety, the authors are grossly misleading and inaccurate in their reference to our products. Since these Kollsman instruments are in general and often compulsory use in both commercial and military aviation, any imputation as to their reliability is a matter of public interest. We feel, therefore, that the facts should be set straight.

In the December (1952) issue of The Scientific Monthly, Figure 5, page 377, shows the dial faces of two different altimeters plainly marked Kollsman. The Kollsman "160," or counter, altimeter is referred to in the caption as the "redesigned altimeter face now in use." The three-pointer type is alluded to as "the old-type altimeter face responsible for many accidents (after Grether)." Neither of these statements is true. Here are the relevant facts:

1. In the complete CAB investigations of aircraft accidents covering the years 1948 through 1951, there is not a single instance of an accident attributed specifically to a misreading of the altimeter. These official investigations cover all scheduled, irregular, and Alaskan carrier operations. Approximately 35 per cent of accidents reported are laid to pilot error. Although it is almost impossible to determine all the facts incontestably, it must be admitted that the "complexity" of the altimeter dial and the time needed to read it may have, along with situational tensions, contributed to accidents brought about by pilot error. This, of course, is a far different statement from the one appearing in The Scientific Monthly.

2. The authors of "Human Engineering" credit Walter F. Grether, of the AF Aero Medical Laboratory, with placing accident blame on the altimeter. Actually Grether is basically concerned with the indices of pilot error reading and makes no claim that the multiple-pointer dial is responsible for many air accidents. This is the apposite statement made by Grether in his article in the *Journal of Applied Psychology* (August 1949):

> Numerous fatal and non-fatal accidents have been attributed to such instrument reading errors, and without doubt many of the unexplained crashes *resulted from similar human error* [italics ours].

Dr. Grether's emphasis is significantly different from that of Mead and Wulfeck. As a psychologist he take

due account of the human factor. In his researches on clock readings, for instance, Grether found that even on the best designed 24-hour clocks AF pilots scored a 7 per cent reading error!

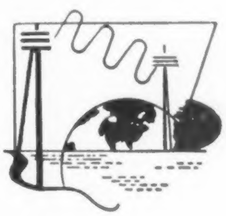
3. Finally, the "redesigned altimeter" referred to by Mead and Wulfeck is not yet in use. Rather, this counter altimeter represents a prototype, a phase of Kollsman research in the direction of simplifying the altimeter dial. Encouraged by the USAF, we developed this model partly in answer to a study by Grether in which he demonstrates the types of error likely to occur in reading the multiple-pointer altimeter. The advantages of the counter dial are made evident in the Grether study; however, the mechanical problem of introducing such a counter into a pressure altimeter design has been tremendous. Its solution has depended upon an almost total reduction of friction so that delicate diaphragm impulses might be translated into accurate counter readings. We are hoping to begin volume production on this counter altimeter shortly.

MILLA ALIHAN
Kollsman Instrument Corporation, New York

DR. ALIHAN's letter of February 18 was most appropriate. We are guilty of the kind of error that so often occurs when two or more people work on the same paper. The caption for Figure 5, page 377, of our article should have been worded "redesigned altimeter face proposed for use" and "the old-type altimeter face responsible for many reading errors." To follow the text and the experimental data, strictly for the record, no relation between altimeter face and accident rate should have been implied.

Certainly Kollsman Instrument Corporation is to be congratulated and admired for its great interest, enthusiasm, and cooperation in working toward the goal of greater safety through greater instrument legibility and interpretability. It was most certainly *not* our purpose to deprecate its product by identifying it as "responsible for many accidents."

JOSEPH W. WULFECK
Institute for Applied Experimental Psychology
Tufts College



SMO ON THE AIR

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WOI-FM, Ames, Iowa	Iowa State College of Agriculture and Mechanic Arts (Articles of Interest)	7:45 P.M.
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WEVD, New York City	Wendell W. Rázim (Science for the People)	9:00 P.M.
	Wednesday	
CKPC, Brantford, Ont.	The Telephone City Broadcast Limited (Modern Science)	9:45 P.M.

The Editor of THE SCIENTIFIC MONTHLY will be glad to cooperate with university or other educational stations interested in securing scientific material suitable for broadcasting.

ASSOCIATION AFFAIRS

A REPORT OF THE ST. LOUIS MEETING DECEMBER 26–31, 1952

GOOD weather, the enthusiastic cooperation and interest of St. Louis citizens, and warm hospitality on the part of local scientists combined to make the 119th meeting of the American Association for the Advancement of Science a decidedly pleasant and memorable occasion. The Academy of Science of St. Louis arranged a luncheon at which the Executive Committee and administrative staff of the Association were guests, and many resident scientists invited out-of-town speakers and colleagues to their homes. Apart from its friendliness, this annual meeting of the AAAS was one of the most important and significant conventions in the long history of the Association, now in its 105th year.

The sixth St. Louis meeting was noteworthy in more than one respect. Among the items of business transacted in the two sessions of the Council, at which 106 members were present, was the adoption, by unanimous vote, of a sixth constitution and a new set of bylaws that will, it is hoped, enable the Association more efficiently to continue its work of advancing science. The Academy Conference, with 29 academies officially represented, had a particularly successful series of sessions. This recurrent conference and the Conference on Scientific Manpower were joined this year by a Conference on Scientific Editorial Problems, which was so well received that the participants decided to organize it, also, to continue at future AAAS meetings. The special sessions, which add so much to the meetings each year—the distinguished evening addresses sponsored by the American Mathematical Society, the National Geographic Society, the Scientific Research Society of America, the Society of the Sigma Xi, and the United Chapters of Phi Beta Kappa, as well as the presidential address of the AAAS itself—attracted large and appreciative audiences. The AAAS Science Theatre, which showed the latest in foreign and domestic scientific films, was consistently well patronized. The Annual Exposition of Science and Industry, with 72 exhibitors and 116 booths filling Convention Hall of the Kiel Auditorium and overflowing into the promenade, was up to the high standard of recent years and drew an appreciative audience. There were programs in all principal fields of science and there was a universal concurrence of opinion regarding their high quality. All these aspects of the meeting merit more than passing mention.

Symposia. The number and quality of the symposia were impressive. The three general symposia were much more than reviews of the literature of their subjects. "Disaster Recovery," with eminent authorities from a variety of fields, analyzed the characteristics of natural and manmade disasters and examined the common principles of recovery. "Applications of the Theory of Games" pleased the mathematicians and statisticians, and interested the laymen who attended. In "The Nation's Nutrition," eight national leaders in the field presented, primarily, their own most recent research. With highly qualified discussants in addition, this program commanded a gratified audience that exceeded two hundred in number.

Another highlight of the meetings—an innovation that proved popular and will be repeated—was the series of four public discussion book panels arranged by the Society of Systematic Zoology and cosponsored by Section F. These sessions, set up in TV fashion with authors and discussants present, drew audiences approaching two hundred. Audience participation was encouraged and, in one of the panels on evolution, spirited discussion prolonged the session long beyond the scheduled time.

The 18 sections and subsections of the Association, together with the 35 participating societies and other organizations that had programs of their own, arranged 62 symposia and panel discussions—a record-breaking total that surpassed the previous high of 42 at the Philadelphia meeting of 1951. All were of high caliber, but with 90 sessions and 381 speakers, there was competition that cut attendance at some programs during the four-day period in which most of them were concentrated. Most program chairman expressed satisfaction with the attendance.

The proportion of symposium papers to short contributed papers was high because relatively few of the larger scientific societies met with the Association this year. Of the 53 organizations that participated, 35 had programs of their own and, of these, only 24 had sessions for contributed papers. For many of these participating groups, however, either it was not their national meeting or their memberships are modest in size. Their participation, it should be emphasized, manifested their interest in the AAAS and the work it is doing, and their contributions were substantial.

At St. Louis, the emphasis on symposia and panels constituted a further advance toward the point of view developed in the Arden House Conference—that AAAS meetings should offer programs that not only will provide opportunities to integrate the several scientific disciplines but will also serve to increase public understanding and support of science. How best to attain these worthy objectives merits careful study. A general symposium, planned in part for intelligent laymen who are local residents, must have a strong social appeal if it is to compete successfully with the daily routine and social habits of business and professional persons. A technical symposium can be expected to attract specialists but it is handicapped if it stands alone and is not supported by paper-reading sessions in the same field. Individual scientists, who attend a scientific meeting primarily to

read a paper and to hear several others in their specialty, constitute an important and receptive audience for symposia that integrate the sciences, develop neglected interdisciplinary areas, or deal with problems of common concern to all scientists. The number present at a AAAS meeting is in direct proportion to the number of contributed papers. At St. Louis ten AAAS sections contributed substantially to the attendance by arranging 25 sessions at which 165 contributed papers were read. Indeed, the 24 societies that had scheduled 54 sessions for paper-reading reported only an additional 209 short papers, of which 94 were given before the three mathematical societies.

A number of section secretaries and others interested in scientific meetings have independently reached the following basic conclusions:

1. Most people go to meetings primarily to see other people in their own or allied fields.
2. The reading of a paper commonly means financial assistance to the author in getting to the meeting.
3. Advance publication of the program, by providing a partial list of those who will be present, stimulates attendance.
4. Once at the meeting, the individual scientist enjoys the symposia and general sessions that are available, but only exceptionally can a scientist afford to attend symposia at a meeting in which sessions for contributed papers in his field are nonexistent.

As long as a AAAS meeting has a core of sessions for contributed papers, a good potential "core attendance" for symposia is assured, and it is gratifying to know that the number of contributed papers will increase at the AAAS Boston meeting of December 26–31, 1953, because full-scale national meetings of the American Society of Zoologists, the American Society of Naturalists, the Genetics Society of America, the American Society of Human Genetics, not to mention sessions of other societies, are scheduled to take place in conjunction with the 120th meeting of the Association.

Participating Societies at St. Louis. In addition to the 18 sections and subsections of the Association, a total of 53 societies and other organizations officially participated in the 119th meeting.

An analysis of the 264 separate sessions of the St. Louis meeting yields some interesting statistics (Table 1).

TABLE 1

Number of sessions for contributed papers	79
Number of symposia and panels	95
Number of business sessions	32
Number of meal functions (at many of which addresses were given or business transacted)	27
Number of round-table sessions or conferences	10
Number of sessions devoted exclusively to addresses	21
Total	264

There were at least 912 speakers, including authors of contributed papers, 374; authors of symposium papers and panel members, 403; discussants, 83; speakers giving introductions and principal addresses, 52.

Attendance. The official number of registrants (exclusive of representatives of the press, exhibitor personnel, and others who assisted with the conduct of the meeting) was 1938. At first thought, this may seem to be an exceptionally low number for a AAAS meeting, whereas, actually, this figure does not compare unfavorably with past meetings in St. Louis, nor does it even approximate the total attendance. Two experiments apparently account for the low registration: One was the sale of copies of the General Program–Directory to institutions and to individuals, separately, at cost ($1.50), without requiring registration. Programs sold in this way totaled 626. Although not every purchaser attended the meeting, there is reason to believe that a substantial number did, without completing their registration by paying an additional dollar for a convention badge. Second, because of the high degree of local support and cooperation, President Bronk proclaimed that all sessions of the meeting would be thrown open to interested adults and college students in Greater St. Louis. This proclamation, which was widely publicized locally, brought many persons, at least to the special sessions and the exposition, who otherwise might not have come at all. At the same hour on Monday evening, Dec. 29, for example, the National Geographic lecture in the Opera House had an audience of 3400; the Sigma Xi address in the Gold Room of the Hotel Jefferson enjoyed an attendance of 1000; the mathematicians' dinner had several hundred; more than 100 geologists were at Washington University; the science teachers had events at the Hotel De Soto; and there were scheduled sessions in psychology, the social sciences, and medicine. It is a conservative estimate that during the meeting a total of 8000 different persons attended one or more phases of the meeting.

TABLE 2

DISTRIBUTION OF REGISTRANTS BY STATES AND COUNTRIES

Alabama	15	North Carolina	10
Arizona	1	North Dakota	2
Arkansas	21	Ohio	86
California	40	Oklahoma	28
Colorado	23	Oregon	4
Connecticut	20	Pennsylvania	45
Delaware	3	Rhode Island	7
District of Columbia	60	South Carolina	3
Florida	15	South Dakota	6
Georgia	5	Tennessee	34
Idaho	5	Texas	36
Illinois	265	Utah	9
Indiana	80	Vermont	1
Iowa	57	Virginia	31
Kansas	55	Washington	6
Kentucky	15	West Virginia	9
Louisiana	17	Wisconsin	40
Maryland	42	Canada	14
Massachusetts	25	Cuba	1
Michigan	76	England	1
Minnesota	37	Finland	1
Mississippi	11	India	1
Missouri	495	Israel	2
Montana	5	Mexico	1
Nebraska	32	New Zealand	1
New Jersey	32	Philippines	1
New Mexico	2	Venezuela	1
New York	103	Total	1938

The registration totals for the two previous meetings in St. Louis—2649 (March 1946) and 2292 (December 1935)—afford an interesting comparison. At these two earlier meetings, the botanical societies, the entomologists, the parasitologists, the geneticists, the horticulturists, the American Society of Zoologists, and other societies all held their annual national meetings with the AAAS. In 1952, without any of these organizations participating, registration was only 700 lower than the registration at the fifth St. Louis meeting in 1946. If allowance is made for the effects of the separate sale of programs and the proclamation of an open meeting, this year's attendance may have been considerably larger than that of March 1946.

At the Philadelphia meeting in 1951, the registration of 3702 exceeded the 3339 registrants of the 1940 meeting in that city, despite the fact that most of the societies mentioned above, and still others, took part in 1940 but not in 1951. Thus, for two consecutive years, it has been demonstrated that, with a core of paper-reading sessions in the sciences proper, there is an audience for the symposia, the conferences, and the special sessions that are distinctive features of the annual meeting of the Association. Analyses of the registration, geographically and by subject fields, are given in Tables 2 and 3.

TABLE 3

SUBJECT FIELDS OF REGISTRANTS

Mathematics	46
Physical Sciences	
Astronomy	16
Physics	116
Chemistry	204
Geology and Geography	106
Engineering	65
Biological Sciences	
Botanical Sciences	198
Industrial Microbiology	32
Zoology	244
Other Biology	88
Medical Sciences	
Dental Research	36
Pharmacy	65
Other Medicine	317
Psychology	72
Anthropology	29
Social Sciences	47
Science Teaching and Education	174
General	83
Total	1938

An inspection of these data indicates that the 119th meeting was definitely a national meeting, with only four states (Maine, New Hampshire, Nevada, and Wyoming) unrepresented.

Detailed comment on the analysis of subject fields seems unnecessary. Two of the paradoxes of the registration are the small number of mathematicians, not withstanding the fact that the mathematical societies officially met with the AAAS, and the large number of botanists, with not a single botanical society meeting with the Association.

The St. Louis Reception Committee. The Preconvention Issue of SCIENCE (**116,** 611 [1952]) listed all those who served on the Executive Committee and the several subcommittees of the St. Louis Reception Committee, and who, in one way or another, contributed to the success of the convention. The Association was fortunate in having as general chairman, Charles Allen Thomas, president of the Monsanto Chemical Company. He maintained an interest in all phases of the meeting and welcomed the Association to St. Louis upon the occasion of the AAAS Presidential Address of Kirtley F. Mather. To Dr. Thomas and his executive assistant, Philip R. Tarr, the Association is greatly indebted.

Annual Exposition of Science and Industry. The Annual Exposition of Science and Industry is well established as an integral and important feature of the annual meeting of the Association. As its title implies, it provides those who use the tools and materials of science and those who produce and distribute them an opportunity to meet each other. The 1952 Exposition, with 72 exhibitors and 116 booths, which filled Convention Hall of the Kiel Auditorium and overflowed into the promenade, did not fall short of the high standard of recent years. In addition to the latest and best in scientific books, instruments, and laboratory supplies, there were excellent special exhibits and a splendid series of technical exhibits of large industrial firms which are coming to realize the advantages of showing their latest technological accomplishments to an appreciative, highly trained, professional attendance.

Potential exhibitors in the St. Louis area were approached through a vice-chairman of the St. Louis Reception Committee, and the Association is conscious of its obligation to Leslie J. Buchan, vice chancellor and dean of the faculties, Washington University, for his personal efforts and keen interest throughout. In addition to the exhibitors listed on pages 619–25 of the December 5, 1952, issue of SCIENCE, the following had booths:

Anheuser-Busch, Inc.
Denoyer-Geppert Company
Folkways Records & Service Co.
General Van & Storage Company, White Motor Company and Fruehauf Trailer Co.
Hospital Topics and *Northwest Medicine*
E. Leitz, Inc.
Ludlow Saylor Wire Company
McDonnell Aircraft Corporation
Missouri Bureau of Public Health Engineering
Natkin & Company, Inc.
Nuclear Research & Development, Inc.
Phillips Scientific Corporation
Westinghouse Electric Corporation

Booth space was endowed by:

Nooter Corporation
Olin Industries, Inc.
Southwestern Bell Telephone Company
The Technicon Company
Union Electric Company of Missouri

RAYMOND L. TAYLOR
Assistant Administrative Secretary, AAAS

BOSTON, 1953

THERE is no substance to the rumor that the AAAS relaxes or leaves on winter vacations as soon as the Christmas meeting of the Association is over. Work on the next annual meeting fits into the administration schedule as tightly and as quickly as an interchangeable part in a piece of machinery, which, with some adjustments for the new job to be done, continues to function with little more than a momentary pause.

The story of any annual meeting spreads over several years, as the case of Boston illustrates. As far back as the spring of 1950, Raymond L. Taylor studied The Hub's physical facilities and tentatively reserved all of them for Association use in December 1953. The AAAS Executive Committee designated Boston as the 1953 meeting place in October 1950; and promptly thereafter the tentative arrangements made by Dr. Taylor were confirmed. Correspondence was then started to stimulate thinking on the broader aspects of the program.

In late 1952, despite preoccupation with the final details of the St. Louis convention, the tempo was accelerated. Earl P. Stevenson, president of Arthur D. Little, Inc., agreed to serve as General Chairman of the Local Committee; and James B. Conant and James R. Killian readily agreed to work with Dr. Stevenson in the capacity of vice-chairmen. This situation was, of course, altered when Dr. Conant resigned from the presidency of Harvard to accept appointment as U. S. High Commissioner for Germany, but not before he had made several invaluable suggestions. Among them was the thought that, as a thread running through the fabric of the meeting, some such theme as "The Interface of Land and Sea" would enable the Association to make the most of the New England environment and of a special field of investigation in some of its institutions.

Meanwhile several affiliated societies have given thought to the feasibility of meeting with the Association at Boston, and a few—the American Society of Zoologists, the Society of Systematic Zoology, the American Society of Naturalists, Genetics Society of America, the American Society of Human Genetics, the science teachers, and others—have decided in favor of it, and at least a score more have indicated their interest in participating.

Although only a few weeks of 1953 have elapsed as this issue goes to press, key posts on the Local Committee have been filled, the personnel of the Symposium Committee has been selected, meetings of these committees and their subcommittees had been scheduled for early March, floor plans and contracts for booth space at the Exposition were ready to go to the printer for distribution March 15, specific programs are taking form—and administrative thoughts wander, perhaps from force of habit, to the Golden Gate and 1954, where the machinery is running smoothly—although idling—in preparation for the Association's first national meeting on the Pacific rim.

If there is no substance to the rumor of post-convention relaxation for the staff, there is even less to the unfounded impression that the Association's meetings are "outmoded," that its "programs have grown 'thinner'." Neither facts nor figures bear out these defeatist statements. Where else but at a AAAS convention can engineers, biologists, psychologists, industrialists, physical scientists, and public leaders assemble to consider Disaster Recovery? Or the Interface of Land and Sea? Or Problems of the Pacific Rim? It is not the Association that lags, but those who fail to comprehend the scope and the impact of its current program. Intellectual bankruptcy and deterioration will indeed set in if the AAAS turns from programming important science merely to ballyhooing the importance of science.

HOWARD A. MEYERHOFF

GLADYS M. KEENER, executive editor, SCIENCE and THE SCIENTIFIC MONTHLY, and HOWARD A. MEYERHOFF, administrative secretary, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, and chairman of the Editorial Board, will voluntarily discontinue their duties with the Association on March 31, and will subsequently submit their resignations. Their reasons for taking this step, announced to the directors a month ago, are administrative. Although the Publications Committee has formulated publication policy and is responsible for the directives under which the journals are operated, the editors have been repeatedly and severely criticized by the president, E. U. Condon, both for the content of SCIENCE and for its rigorous editorial standards. Critical of AAAS journals and meetings, the president-elect, Warren Weaver, took vigorous exception to the editorial "Boston, 1953," (reprinted above from SCIENCE, **117**, adv. p. 3 [Feb. 20, 1953]), in which the administrative secretary reaffirmed the soundness of current AAAS policies and attempted to correct the unfortunate impression created by misstatements attributed to Drs. Condon and Weaver in a press interview. Although Mrs. Keener and Dr. Meyerhoff have been asked to remain in their posts, they choose to withdraw in the interest of harmony and from a desire not to hamper the two administrations to follow that of Detlev W. Bronk, retiring president and chairman of the Board of Directors, whose administration they wholeheartedly support. Mrs. Keener has been with the Association since 1945 and has been executive editor of both journals since 1950. Dr. Meyerhoff succeeded the late F. R. Moulton as administrative secretary in January 1949, and had prior service as secretary of Section E (1937–40), elected member-at-large of the Council (1941–44), vice president and chairman of Section E (1944), and executive secretary (1945–46). No announcement has been made with reference either to their future plans or to their successors.